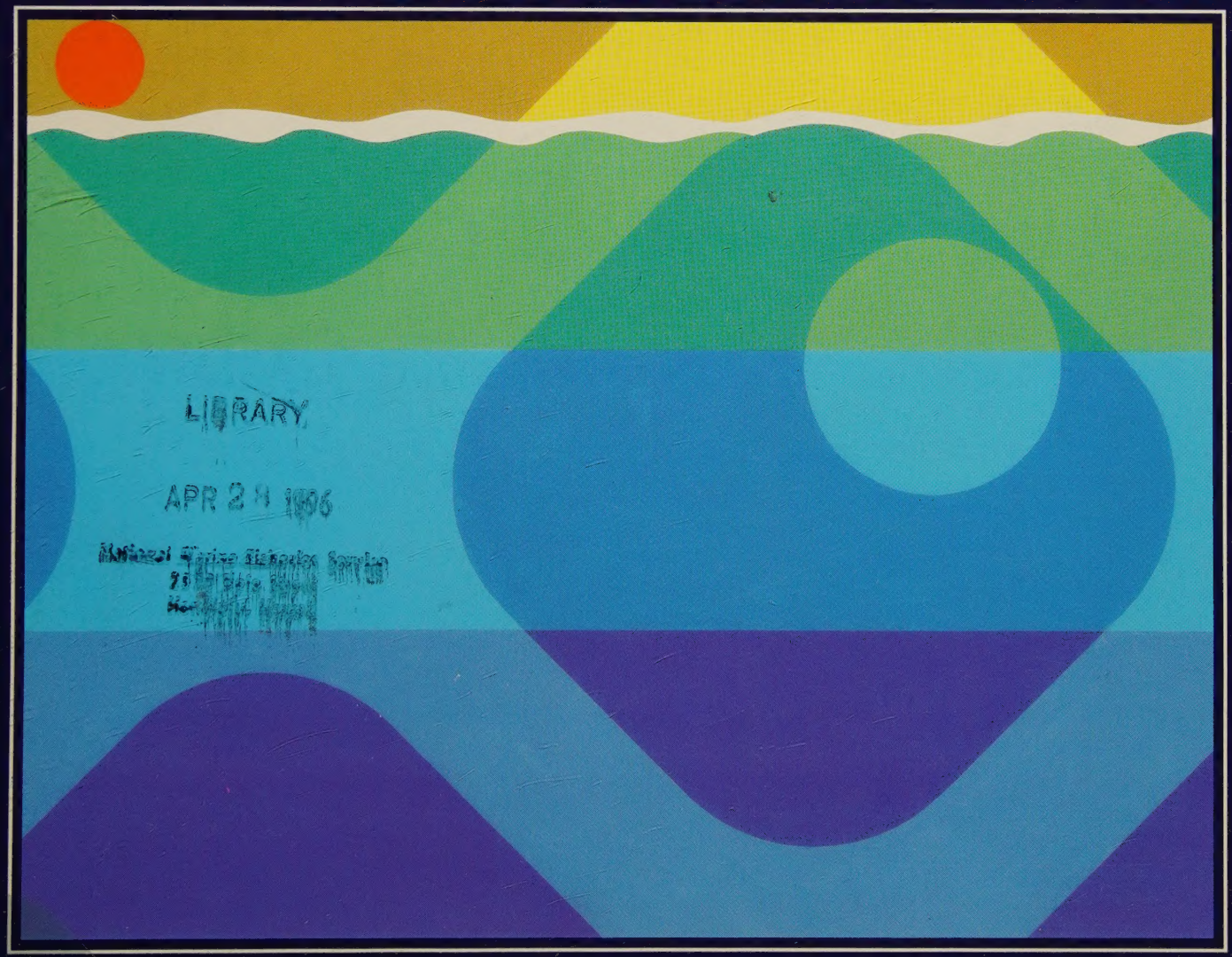
Our Living Oceans

Report on the Status of U.S. Living Marine Resources • 1995



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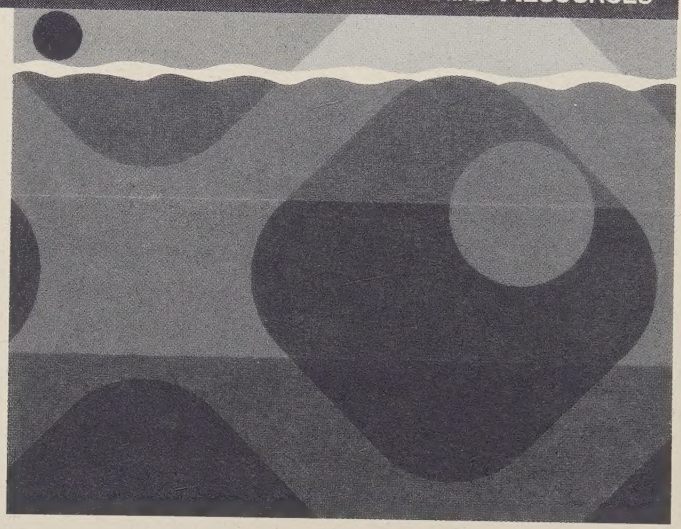
REPORT ON THE STATUS OF U.S. LIVING MARINE RESOURCES

1995



February 1996
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U.S. Department of Commerce

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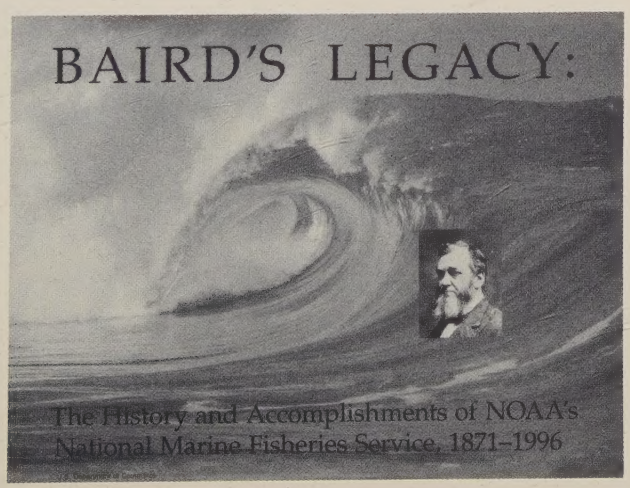
Commemorating 125 Years of Federal Fisheries Science

During 1996, the National Marine Fisheries Service celebrates its 125th anniversary as the Nation's oldest natural resource conservation agency. In 1871, the United States Congress established the Commission of Fish and Fisheries. As an independent agency, the Commission's charge was to protect, manage, and restore the country's fisheries through scientific research.

In time, a new name was accorded the agency reflecting the growth in its responsibilities—the United States Bureau of Fisheries—and in 1903, a new home in the Department of Commerce and Labor. Following a 1939 reorganization into the Interior Department, the agency merged with the Biological Survey to become part of a new Fish and Wildlife Service in 1940. By 1956, the agency was again operating within the Interior Department as a distinct organization—the Bureau of Commercial Fisheries. The agency's last move came in 1970 when, under Executive Order 11564, the Bureau was renamed the National Marine Fisheries Service and placed in the newly created National Oceanic and Atmospheric Administration.

From its inception, the Service has contributed broad scientific advances in marine biology, fisheries science, and oceanography. The vision of its first Commissioner, Spencer F. Baird, Secretary of the Smithsonian Institution and an eminent zoologist of his time, is honored by a continuing commitment to scientific excellence and federal stewardship.



As part of the 125th anniversary celebration, the Service's Scientific Publications Office has published a chronicle of the agency's activities—"Baird's Legacy: The History and Accomplishments of NOAA's National Marine Fisheries Service, 1871-1996." ❑

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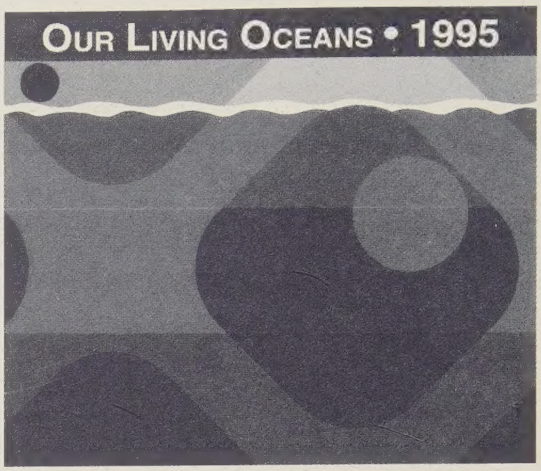

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Our Living Oceans

1995

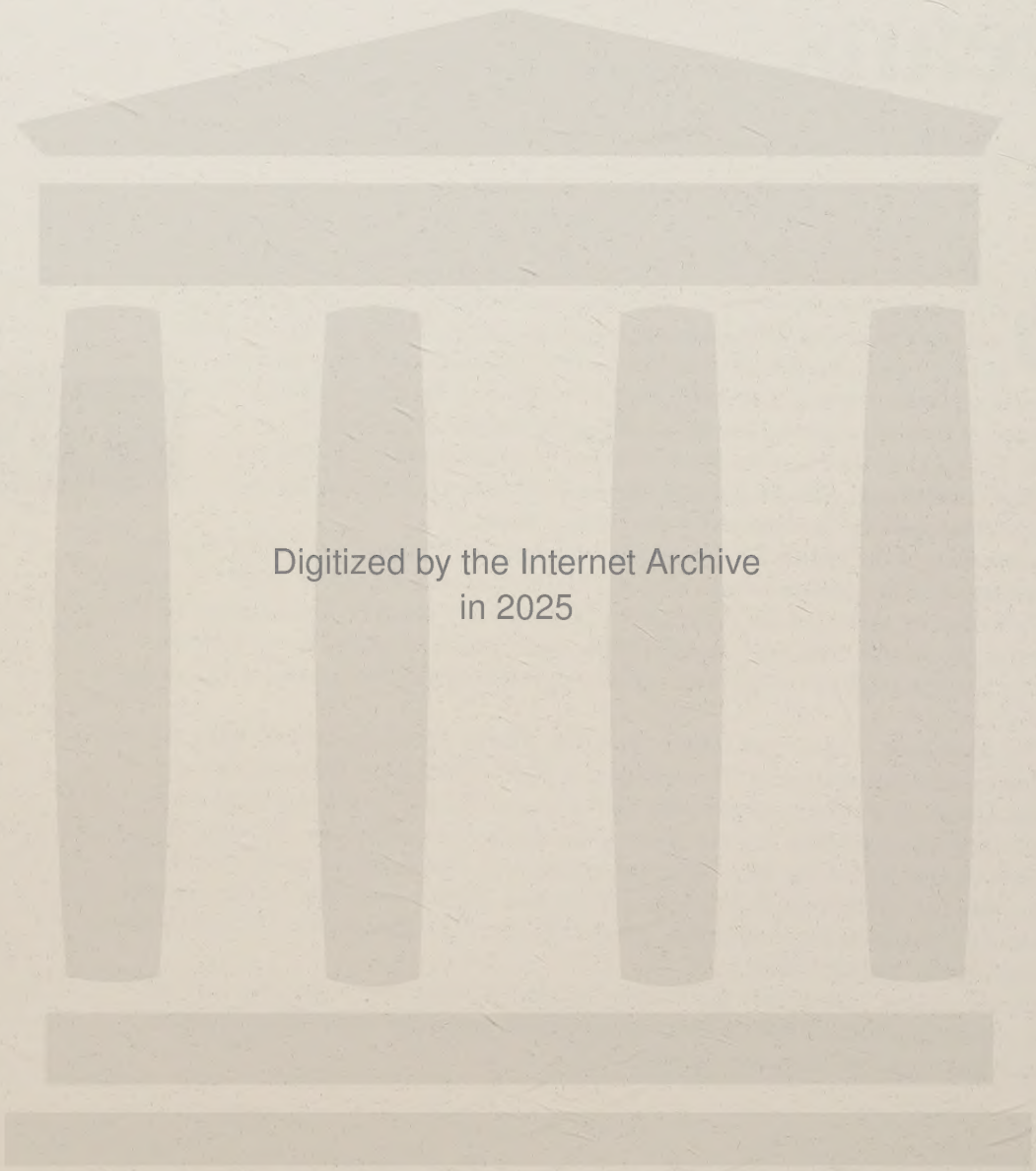
Preface

Our Living Oceans 1995 (OLO '95) is the fourth volume in a recent series of reviews on the status of U.S. living marine resources. Earlier editions of "Our Living Oceans" were published for the years 1991, 1992, and 1993. This volume also inaugurates a biennial reporting schedule; this schedule better captures the often extended period of time required to observe and document changes in the marine environment. The OLO series cover resources from five large geographical regions of the United States: Northeast, Southeast (including the Gulf of Mexico and Caribbean), Alaska, Pacific coast, and the far western Pacific oceanic waters.

The stewardship of the Nation's living marine resources largely is entrusted to the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (hereafter referred to as NOAA Fisheries), an agency of the Department of Commerce. NOAA Fisheries carries out this responsibility in partnership with eight regional fishery management councils, three interstate marine fishery commissions, all coastal states, and many international marine science and management organizations.

OLO '95 focuses on the principal fishery resources, marine mammals, and sea turtles that are under the management jurisdiction of NOAA Fisheries. It also summarizes the status of many nearshore species which are managed primarily by the coastal states. This report provides the estimates of fishery stock productivity and status of the resources through 1994. The assessments are drawn from results of field surveys, biological and physical studies, and independent monitoring of the recreational, subsistence and commercial fisheries. The level of fishery utilization and management of the resources are summarized. Also, important local and national issues, as well as the near-term outlook, are highlighted.

As with the previous editions of "Our Living Oceans," the information provided here is the result of the collective efforts of NOAA Fisheries staff from around the country. The principal contributors to this report are listed in Appendix 1. ❑



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Foreword

The National Oceanic and Atmospheric Administration's National Marine Fisheries Service began as the U.S. Commission of Fish and Fisheries in 1871. This year, the Service celebrates its 125th anniversary of scientific endeavor and fisheries management. NOAA Fisheries is entrusted with the conservation and management of fish, shellfish, sea turtle, marine mammal, and other resources that live in U.S. waters. We work on behalf of the American public to manage and sustain the Nation's living marine resources and their habitats.

NOAA Fisheries advocates sustainable use of living marine resources. These uses include commercial, subsistence and recreational fishing, observation, and research. We support maximizing benefits to the Nation, without compromising the coexistence of species and their habitats. We strive to balance competing public needs and interests in the use and enjoyment of our ocean's resources.

NOAA Fisheries is responsible for ensuring that the best scientific information is used in management decisions. Our data collection and research are conducted over a broad range of scientific disciplines, including the natural and social sciences. Our scientists conduct research that contributes to the knowledge of fisheries science and the design of innovative management approaches. These efforts are augmented by improvements in the agency's monitoring and enforcement capabilities.

NOAA Fisheries supports the open exchange of information. Effective communication is essential to the development and support of successful resource management and conservation policies. We believe that an informed public can help us reach attainable and measurable objectives. This report is an example of our continuing efforts to inform the American people of our science-based findings.

NOAA Fisheries is fundamentally dedicated to maintaining the Nation's marine heritage by ensuring the existence of productive, diverse, and healthy ocean ecosystems. Our long history has given us the experience and expertise to make progress towards resolving living marine resource issues. This report shows the many areas where improvement is needed. We must reverse the path to overfishing, rebuild and maintain sustainable fisheries, improve economic performance, and strengthen the conservation of protected species and the marine habitat.

As Assistant Administrator for Fisheries, I will focus on our performance in improving the management of U.S. living marine resources through better understanding of ocean science, careful reviews of resource status, improved communications with our constituents, and a more streamlined and effective NOAA Fisheries.

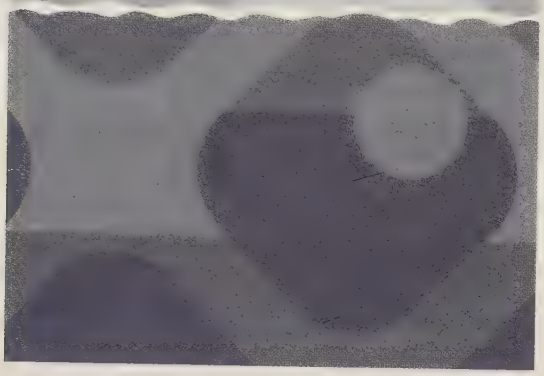
This report provides an overview of the Nation's living marine resources and illustrates the successes and shortcomings in our stewardship of them. It highlights the progress we have made, and more importantly, the significant issues which we must face over the coming years. ❑

Rolland A. Schmitten

Assistant Administrator
for Fisheries
National Oceanic and
Atmospheric Administration

February 1996

Part 1 National Overview



National Overview

Introduction

The United States ranked fifth in the world for fisheries landings as reported by the Food and Agriculture Organization (FAO) of the United Nations in 1993, its latest survey year. The U.S. catch was 5.9% of the world's total catch of marine and freshwater fisheries products. The FAO survey also ranked the United States second in value for imports as well as exports of these products.

The stewardship of the U.S. living marine resources (LMRs) is entrusted to the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (hereafter referred to as NOAA Fisheries or NMFS) which carries out its charge under many laws, treaties and mandates from the U.S. Congress. Most of NOAA Fisheries conservation responsibilities emanate from four statutes: the Magnuson Fishery Conservation and Management Act (MFCMA) regulates fisheries within the U.S. Exclusive Economic Zone (EEZ), the Endangered Species Act (ESA) protects species threatened or endangered, the Marine Mammal Protection Act (MMPA) regulates taking of marine mammals, the Fish and Wildlife Coordination Act authorizes collection of fisheries data and coordination with other agencies for environmental decisions affecting LMRs. A fifth statue, the Federal Power Act, provides for concurrent responsibilities with the U.S. Fish and Wildlife Service (USFWS) for protecting aquatic habitat.

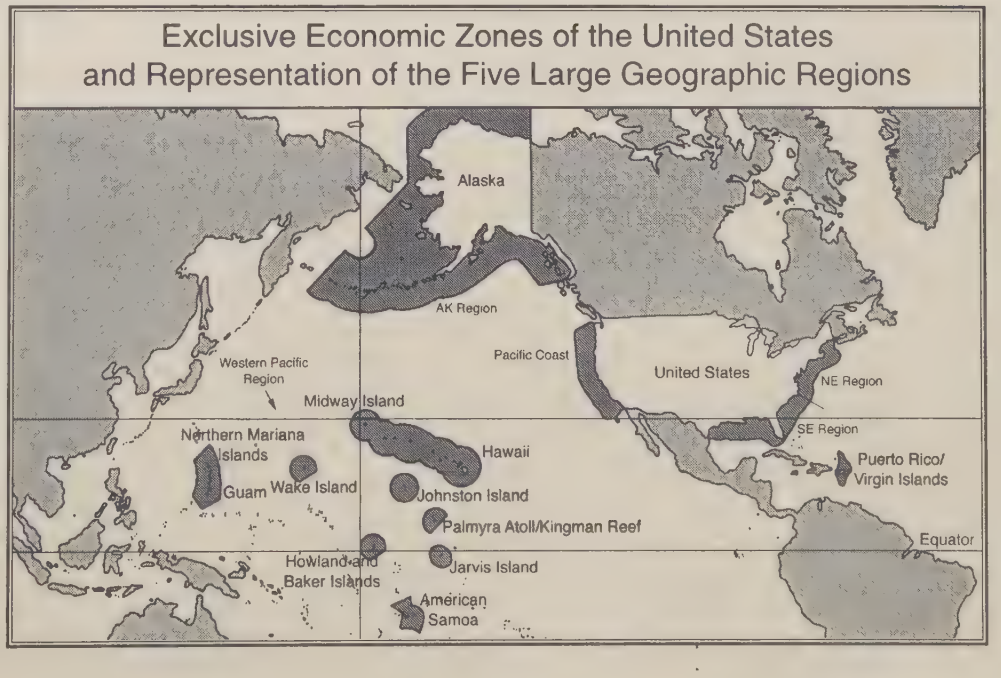
The purview of NOAA Fisheries is the U.S. EEZ or the 200-nautical mile (nmi) zone off the United States (Fig. 1). Within the 0-3 nmi territorial sea, management jurisdiction belongs to the coastal states. Beyond the 200-nmi federal zone are international waters where living marine resources are intended to be regulated by applicable international laws and multilateral arrangements between governments. NOAA Fisheries plays an important role on behalf of the U.S. in the implementation of these international arrangements.

The intent of federal resource conservation laws requires that the best scientific information be used as the basis for management actions. NOAA Fisheries scientists collect and analyze much of this data. From these databases, the agency prepares scientific reports along with technical presentations to fishery managers, industry groups, and the public for use in formulating sound policies governing the use and protection of LMRs.

Ultimately, the Secretary of Commerce has management responsibility as the designated manager of the Nation's living marine resources within the U.S. EEZ. The fisheries resources are managed largely through well documented fishery management plans (FMPs). These management plans are developed through extensive consultations with state and other federal government agencies, public interest groups, and, in pertinent cases, international science and management organizations.

The FMPs originate through the MFCMA which established eight regional fishery management councils (FMCs) to develop management plans for the Nation's fishery resources (Appendix 2). The Councils represent diverse interests through their members who are nominated by state governors in each region and appointed by the Secretary of Commerce. For some fisheries and for protected resources such

Figure 1.



Common Terms

Most of the technical terms or phrases used in this report are defined in Appendix 4; the most common are reviewed here.

- **Stock** ideally refers to a biologically isolated group of organisms (e.g., fish) that are genetically related. Since stocks intermix in the marine habitat, it may be necessary to consider all of the individuals of a species or several species in a geographical area as a stock when it is impractical to isolate them. Thus, a unit stock defined for management purposes may not necessarily correspond to a genetic unit.

- **Recent Average Yield (RAY)** is equivalent to the recent average catch. Unless otherwise designated, RAY is the reported fishery landings averaged for the most recent 3-year period of workable data, 1992-94.

- **Current Potential Yield (CPY)** is the current potential catch that can be taken depending on the current resource abundance and prevailing ecosystem considerations. This term is analogous to acceptable biological catch (ABC) that is specified in some FMPs.

- **Long-Term Potential Yield (LTPY)** is the maximum long-term average catch that can be achieved from the resource. This term is analogous to the concept of maximum sustainable yield (MSY).

- **Stock Level Relative to LTPY** is a measure of stock status. The present abundance level of the stock is compared with the level of abundance which on average would support the LTPY harvest. This level is expressed as below, near, above, or unknown relative to the abundance level that would produce LTPY.

- **Status of Resource Utilization** describes the level of fishery use of the resource (i.e., underutilized, fully utilized, overutilized, or unknown). It shows how the existing fishing effort compares with those levels necessary to achieve LTPY.

- **Threatened** or **Endangered** are terms defined under the Endangered Species Act. A species is considered endangered if it is in danger of extinction throughout a significant portion of its range; it is threatened if it is likely to become an endangered species.

- **Potential Biological Removal (PBR)** is the sustainable removal level (in numbers) for marine mammals as calculated by the 1994 Amendments to the MMPA.

as marine mammals and sea turtles, FMPs and protected species recovery plans may be developed directly by NOAA Fisheries, with advice from the public and the regional FMCs.

This report covers most of the LMRs that are of interest for commercial, recreational, subsistence, or aesthetic reasons to the United States. The status of fishery resources is reported by regional units. Current and potential harvest levels are given, along with information on fishery utilization and management. The status of the marine mammal and sea turtle resources are included. Nearshore species, largely the management responsibility of coastal states, are also summarized.

The information contained in this report has been collected from many sources. Ideally, the most current peer-reviewed stock assessment reports and publications, which serve as the scientific basis for management, are used. For some species, stock assessments may not be complete owing to lack of data, but they may still be adequate for fishery scientists to exercise professional judgments as to stock status and magnitude of potential yields. When information is inadequate, the status is classified as unknown. In such cases, potential yield would be estimated from recent catch levels. More detailed information on specific resources may be obtained from regional status of fisheries resources reports available from NOAA Fisheries science centers around the country (Appendix 3), and from coastal state fish and wildlife agencies.

Contents

Part 1 of OLO '95 contains a national overview of significant LMRs. It includes this introduction, a brief introduction of terms, region by region resource summaries, a discussion of issues of national concern, and a discussion of near-term outlook. Part 1 also includes two feature articles—an essay on Pacific Northwest salmon, and an examination of the implications of the 1994 Amendments to the Marine Mammal Protection Act.

Part 2 presents in greater detail the status of regional LMRs in 25 separate units. These unit synopses describe species or species groups linked geographically, ecologically, or by characteristics of their fisheries.

Part 3 lists the principal authors and contributors, the FMCs and FMPs, the principal NOAA Fisheries facilities around the country, stock assessment principles and terms, and the scientific and common names of most species covered in this report.

Productivity of Stocks

The productivity and status of fishery resources utilized by the United States are summarized in Units 1 to 21. Productivity is represented by RAY, CPY, and LTPY. For some stocks, the U.S. shares fishery productivity with other fishing nations because these stocks range beyond the U.S. EEZ. For the purposes of this report, the productivity of transboundary species is compiled for the entire stock as well as the prorated portion of the stock within the U.S. EEZ. OLO '95 reports both total productivity and the prorated U.S. share of the stocks based on the ratio of the U.S. RAY to total RAY. The U.S. RAY is taken primarily within the U.S. EEZ; any amount taken outside the U.S. EEZ has generally been small.

The total LTPY of all U.S. fishery resources is estimated at 10.3 million t (Table 1). Total CPY is 9.1 million t, indicating that the present productivity of the stocks is 12% below the long-term potential. Total RAY is 7.2 million t or 30% below the long-term potential.

When only the U.S. prorated share of the resources is considered, the U.S. LTPY is 8.1 million t or 21% below total LTPY (Fig. 2). By region, the percentage distribution of U.S. LTPYs is 10% for the Northeast, 18% for the Southeast, 54% for Alaska, 14% for the Pacific coast, and 4% for the western Pacific oceanic regions (Table 2, Fig. 3).

The U.S. RAY is 5.06 million t or 37% below U.S. LTPY. The additional 37% potential yield was not realized because some of the stocks were underutilized while some have been overexploited and currently no longer producing at their full long-term potential. By region, the percentage distribution of U.S. RAYs is 9% Northeast, 23% Southeast, 54% Alaska, 9% Pacific coast, and 5% western Pacific oceanic (Table 2, Fig. 4).

Status of Stocks

The status of stocks is classified according to the current level of abundance relative to the level that would produce LTPY. Table 3 summarizes the classifications for the 275 stock groups addressed in this report as being 30% below, 27% near, 9% above, and 34% unknown relative to the levels that would produce LTPY. This summary includes 74 stock groups of nearshore resources that are under the purview of coastal states.

Excluding nearshore resources, the remaining 201 stock groups that are under the purview of NOAA Fisheries have been classified as being 36% below, 30% near, 13% above, and 21% unknown relative to the abundance levels that would produce U.S. LTPY (Fig. 5). The 21% unknown category comprise 43 out of 201 stock groups. These 43 stock groups are generally of low abundance and contributed only to 2.7% of U.S. RAY.

There are 158 stock groups whose status are known that fall under the purview of NOAA Fisheries (Units 1-20 in Table 3). In this category, there is a high percentage of stock groups, 46% (involving 73 out of 158 known-stock status), that is below levels that would produce LTPY. The majority of these low

Table 1. Productivity of Fisheries Resources Utilized by the United States

Productivity indicators are expressed in metric tons by long-term potential yield (LTPY), current potential yield (CPY), and recent average yield (RAY) [1]

Unit / Fishery	Entire Range of Stock			Prorated within U.S. EEZ	
	Total RAY	Total CPY	Total LTPY	U.S. RAY	U.S. LTPY
1. Northeast demersals	185,535	183,735	479,335	145,900	402,365
2. Northeast pelagics	165,800	724,300	412,000	115,600	253,920
3. Atlantic anadromous	4,836	4,836	4,836	4,836	4,836
4. Northeast invertebrates	99,500	99,900	72,500	93,568	89,357
5. Atlantic highly migratory pelagics	246,955	242,455	245,519	14,600	19,100
6. Atlantic sharks	9,324	9,213	10,240	9,324	10,240
7. Atlantic/Gulf of Mexico coastal migratory pelagics	17,884	20,127	26,236	17,884	26,236
8. Atlantic/Gulf of Mexico reef fish	31,225	30,750	43,158	31,225	43,158
9. Southeast drum & croaker	16,785	16,785	68,715	16,785	68,715
10. Southest menhaden	890,000	890,000	1,140,000	890,000	1,140,000
11. Southeast/Caribbean invertebrates	112,483	111,641	95,165	112,483	95,165
12. Pacific coast salmon	22,957	33,312	33,312	22,957	33,312
13. Alaska salmon	364,800	296,500	296,500	364,800	296,500
14. Pacific coast & Alaska pelagics	116,800	166,100	559,100	116,800	559,100
15. Pacific coast groundfish	262,657	352,491	465,750	262,657	465,750
16. W. Pacific invertebrates	143	106	135	143	135
17. W. Pacific bottomfish & armorhead	388	626	2,738	388	2,738
18. Pacific highly migratory pelagics	2,077,232	2,003,188	2,033,706	240,438	278,945
19. Alaska groundfish	2,186,684	3,544,525	3,955,025	2,186,684	3,955,025
20. Alaska shellfish	125,744	125,745	113,779	125,744	113,779
21. Nearshore species	283,995	283,995	283,995	283,995	283,995
Total	7,221,727	9,140,330	10,341,744	5,056,811	8,142,371

[1] For row totals; where LTPY is unknown, CPY is substituted; where CPY is unknown, RAY is substituted. RAY is generally for the latest 3-year average, 1992-94.

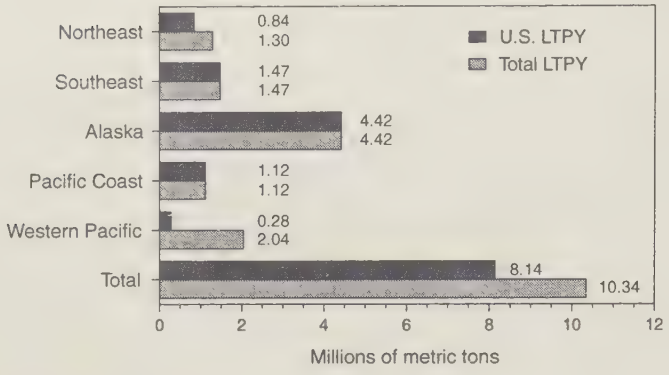


Fig. 2. Total versus U.S. prorated share of fisheries resources.

abundance cases occurred in Unit 1 (19 stocks of northeast demersal species), Unit 8 (9 stocks of Atlantic and Gulf of Mexico reef fish), and Unit 15 (6 stocks of Pacific coast groundfish). Less pronounced cases of low abundance can be found in all regions, including Alaska. For the remaining stocks (85 out of 158 known-stock status), these have been classified as 38% near and 16% above the levels that would produce LTPY. If it is assumed that stocks near or above levels that would produce LTPY are stocks in healthy condition, it may be stated that 54% of the known-stock status groups are at healthy abundance levels.

Status of Utilization

The status of utilization describes the level of use of a fishery resource as being underutilized, fully utilized, overutilized, or unknown. It compares existing fishing effort with the appropriate levels necessary to achieve LTPY.

Table 4 summarizes the classifications for the 275 stock groups addressed in this report as being 12% underutilized, 34% fully utilized, 23% overutilized, and 31% unknown. This grouping includes 74 stock groups of nearshore resources that are under the purview of coastal states.

Excluding nearshore resources, the remaining 201 stock groups that are under the purview of NOAA Fisheries have been classified as 15% underutilized, 35% fully utilized, 28% overutilized, and 22% unknown (Fig. 6).

There is still a high percentage of stocks, 22% (involving 44 out of 201 stock groups), whose status of utilization is unknown. The majority of these 44 unknown stock groups are found in the Southeast region where assessments of coastal migratory species, reef fishes, and invertebrates have been difficult. This category also includes 7 stock groups from Unit 18 occurring in the western Pacific oceanic region where the highly migratory species of tunas move long distances across many national jurisdictions, making assessment of the stocks difficult.

There are 157 stock groups that are classified as being of known-utilization status that are under the purview of NOAA Fisheries (Units 1-20 in Table 4). Of these, 36% (involving 56 out of 157 known utilization-status groups) are overutilized. The majority of these overutilized cases occurred in Unit 1 (18 stocks from the Northeast demersal unit) and Unit 8 (10 stocks in the Atlantic and Gulf of Mexico reef fish unit). For the remaining stocks, they have been classified as 20% underutilized and 44% fully utilized, for a combined total of 64% utilization at under-to-full utilization levels.

Table 2. Regional Productivity of Fisheries Resources Utilized by the United States

Productivity indicators are expressed in metric tons by long-term potential yield (LTPY), current potential yield (CPY), and recent average yield (RAY). Unknown row totals are substituted as in Table 1.

Region	Entire Range of Stock			Prorated within U.S. EEZ	
	Total RAY	Total CPY	Total LTPY	U.S. RAY	U.S. LTPY
Northeast	777,856	1,330,456	1,289,420	449,734	844,808
Southeast	1,168,531	1,169,346	1,474,344	1,168,531	1,474,344
Alaska	2,732,298	4,025,140	4,423,674	2,733,298	4,423,674
Pacific Coast	462,759	609,948	1,116,207	462,759	1,116,207
Western Pacific Oceanic	2,079,283	2,005,440	2,038,099	242,489	283,338
Total	7,221,727	9,140,330	10,341,744	5,056,811	8,142,371

Regional and Species Group Synopses

Northeast Region

The Northeast region's finfish and invertebrates are grouped under demersal, coastal pelagic, anadromous, invertebrate, highly migratory pelagic, and nearshore resources. Their combined U.S. LTPY is 844,800 t (Table 5) out of a total LTPY of 1.29 million t for the region. The lower U.S. LTPY reflects the sharing of transboundary resources with Canada and some Atlantic countries. The

U.S. RAY totaled only 449,700 t or 53% of U.S. LTPY because some 33 species, principally groundfish, are overutilized and below the stock levels necessary to produce LTPY. The RAY of 449,700 t excluded 248,000 t of menhaden that were taken at the southern limit of the Northeast region. That amount has been added to the Southeast menhaden data (Unit 10) as it is an integral part of the South Atlantic menhaden stock.

The mixed-species groundfish fishery has traditionally been the most valuable of the region, followed by American lobster and Atlantic sea scallop. Recreational fisheries for species such as cod, winter flounder, mackerel, striped bass, bluefish, and bluefin tuna are also important and contribute greatly to the region's economy.

Principal groundfish and flounders in the Northeast, particularly cod, haddock, and yellowtail flounder, have been severely overfished and their overall abundance in 1994 was the lowest on record. Dogfish and skates, which increased in abundance beginning in the 1970s as groundfish and flounders decreased, currently comprise about 75% of the total fish biomass on Georges Bank and have supported increased catches in recent years. Since 1990, however, their abundances have also begun to decrease. Catches of other groundfish have become increasingly important in recent years as preferred species declined. In 1994, the U.S. catch of goosefish exceeded the catch of cod for the first time.

Five species, mainly pelagics, are presently underutilized, and the CPY of the two most abundant of these, Atlantic mackerel and herring, is nearly 522,500 t higher than their RAY. The anadromous striped bass, driven to very low levels of abundance in the early-1980s and subjected to severe catch restrictions beginning in the mid-1980s, was declared fully restored in early-1995. The region's valuable crustaceans and bivalve molluscs, both offshore (e.g., American lobster, sea scallop, surfclam, ocean quahog) and inshore (e.g., blue crab, oyster, blue mussel, hard and softshell clam) are nearly all fully or overexploited.

Most of the region's fisheries are included in FMPs either in place or under development. Very few FMPs have been successful in preventing overexploitation of their respective species. Amendment #5 to the Northeast Multispecies FMP, enacted early in 1994, was intended to limit commercial fishing effort on groundfish in New England and prevent the issuance of new vessel permits in this overcapitalized fishery. It is now judged to be insufficient in reducing fishing mortality as desired. In light of the serious nature of the collapse of cod, haddock, and yellowtail flounder, the Secretary of Commerce approved an emergency closure of portions of Georges Bank and a moratorium on commercial fishing for haddock, beginning 1 January 1994, which continues in place. The New England FMC is developing Amendment #7 to the Multispecies FMP, with the objective of reducing fishing mortality on these stocks to as near to zero as practicable. Concurrently,

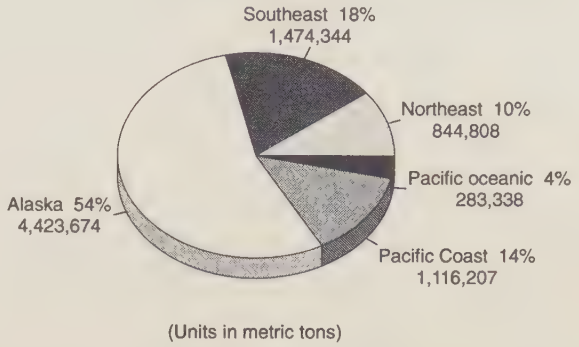


Fig. 3. Regional apportionment of long-term potential yield of the U.S. prorated share of fisheries resources.

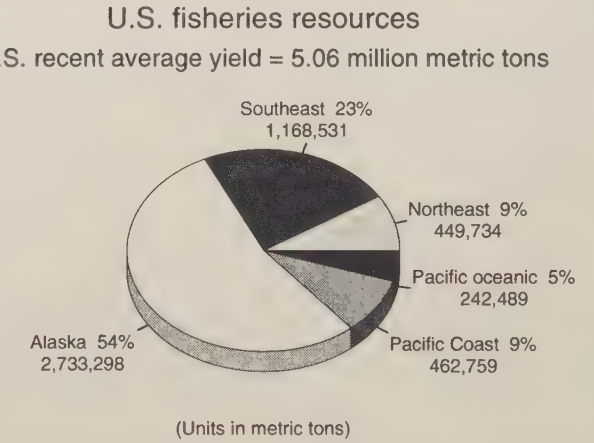


Fig. 4. Regional apportionment of recent average yield of the U.S. prorated share of fisheries resources.

Canada continues to maintain severe restrictions on its own groundfish fishery on Georges Bank to promote stock rebuilding.

Amendment #4 to the Sea Scallop FMP controls fishing effort by limiting the days at sea for each vessel, placing a moratorium on new entrants, and imposing a larger dredge mesh-ring size. Along with supplemental measures, it is intended to reduce fishing mortality and move this fishery from overutilization to full utilization. Plans are underway by the New England FMC to develop additional regulatory measures for American lobster that will include limits on numbers of traps, seasonal closures, and overall quotas.

Southeast Region

The Southeast region covers the Gulf of Mexico, Southeast Atlantic, and the Caribbean Sea. Its important resources are Atlantic sharks, Atlantic/Gulf of Mexico coastal migratory pelagics, Atlantic/Gulf of Mexico reef fish, drum and croaker, menhaden, Southeast Atlantic/Caribbean invertebrates, and nearshore resources. The total LTPY of fisheries resources is 1.47 million t and is virtually all available to the U.S. (Table 6). The U.S. RAY is 1.17 million t or 80% of U.S. LTPY.

Menhaden comprise about 75% of both the U.S. LTPY and U.S. RAY. Menhaden are considered fully utilized in both the Gulf of Mexico and Atlantic Ocean, with some growth overfishing in the Atlantic.

Shrimp led the region in value, although composing only 8% of the total Southeast LTPY and RAY. The three major species (brown, white, and pink) are considered fully utilized in both the Gulf of Mexico and Atlantic. Yields are not now closely tied to shrimping effort—about half the current effort in the Gulf could produce about the same long-term average yield.

The highly migratory pelagic species are important components of fisheries in the Northeast and Southeast regions. Bluefin tuna is well below the biomass level required for maximizing long-term yield. The marlins (white and blue) are below as well, although blue marlin appear to be increasing. Swordfish has recently declined to a level below that which would produce maximum long-term yield. Yellowfin tuna is presently fully exploited and near its maximum long-term yield. Bigeye tuna exploitation has recently increased, but current yields are not expected to be maintained.

Large coastal sharks (as a group) may be overutilized, but the status of each species is presently unknown. Due to their life history strategies, sharks may be particularly vulnerable to overfishing.

Spanish mackerel appear to be fully utilized in both the Gulf of Mexico and Atlantic. King mackerel have been overfished in the Gulf, and a stringent rebuilding program has been in place for the last several years. King mackerel in the Atlantic may have some additional yield potential. The status of other coastal migratory pelagic species in the region is unknown.

Reef fish in the Southeast region include over 200 stocks of more than 100 species currently contributing to fishery yield. The status is unknown for many of these stocks, but several of the major species have been assessed. In the Gulf of Mexico, red snapper are overfished, and a stringent rebuilding plan has begun. Success of this rebuilding hinges on the reduction of bycatch of juvenile red snapper in the Gulf shrimp fishery. Red grouper appears to be fully utilized in the Gulf of Mexico. In the

Table 3. Status of Stock Levels of U.S. Living Marine Resources, 1992-94

Unit / Fishery	Current Status Relative to the Level Producing LTPY				
	Below	Near	Above	Unknown	Total
1. Northeast demersals	19	3	2	1	25
2. Northeast pelagics	1	2	3	0	6
3. Atlantic anadromous	4	0	1	0	5
4. Northeast invertebrates	0	3	2	1	6
5. Atlantic highly migratory pelagics	4	4	0	2	10
6. Atlantic sharks	1	0	1	1	3
7. Atlantic/Gulf of Mexico coastal migratory pelagics	1	3	0	3	7
8. Atlantic/Gulf of Mexico reef fish	9	2	0	17	28
9. Southeast drum & croaker	4	0	0	3	7
10. Southest menhaden	0	2	0	0	2
11. Southeast/Caribbean invertebrates	3	6	0	5	14
12. Pacific coast salmon	2	3	0	0	5
13. Alaska salmon	1	1	3	0	5
14. Pacific coast & Alaska pelagics	3	4	0	0	7
15. Pacific coast groundfish	6	4	4	5	19
16. W. Pacific invertebrates	1	0	0	0	1
17. W. Pacific bottomfish & armorhead	3	3	0	0	6
18. Pacific highly migratory pelagics	2	12	0	1	15
19. Alaska groundfish	6	8	8	3	25
20. Alaska shellfish	3	0	1	1	5
21. Nearshore species	10	14	0	50	74
Subtotal of Units 1-20	73	60	25	43	201
% of Subtotal	36%	30%	13%	21%	
% of 158 "known" stock groups	46%	38%	16%		
Total of Units 1-21	83	74	25	93	275
% of Total	30%	27%	9%	34%	
% of 182 "known" stock groups	45%	41%	14%		

Atlantic region, many of the key species are considered overutilized (e.g., vermilion and other snappers, red porgy, several groupers, amberjacks, jewfish). In the Caribbean, Nassau grouper and jewfish are considered overutilized; the status of other species is unknown.

The status of drum and croaker stocks is largely unknown. Many of the smaller species could also be heavily impacted from bycatch of the shrimp fleet; thus weakfish bycatch in the Atlantic is becoming a major management issue. Red drum harvest in the Gulf and South Atlantic EEZs have been prohibited, and harvests in state waters have been reduced for several years due to low spawning levels. All indications are that fishing mortality has been reduced significantly and recovery is expected.

Status information for invertebrates other than shrimp is mixed. Spiny lobster is apparently overutilized in the Southeast region. Spiny lobster status in the Caribbean is uncertain, but possibly overutilized, with growth overfishing. Stone crab appears to be fully utilized, while queen conch may be overutilized.

Alaska Region

The Alaska region dominates in the tonnage of fisheries resources that could be obtained in the long term for the United States. The major resources are salmon, groundfish, Pacific halibut, shellfish, and herring. Their combined U.S. LTPY is 4.42 million t (Table 7). The resources are generally healthy with regional CPY only 9% below LTPY. The U.S. RAY has been steady at about 2.73 million t, or 38% below LTPY. Catches are substantially below long-term potential because many of the resources, particularly flatfish species, are underutilized.

Alaska salmon stocks have produced bumper harvests in recent years. The RAY of 364,800 t is actually 23% above LTPY because salmon runs have been particularly successful. Five species of Pacific salmon (chinook, coho, sockeye, pink, and chum) contribute to the catch.

The development of a domestic groundfish fisheries off Alaska has been a great success under the MFCMA. Until its implementation in 1977, Alaska's groundfish fisheries, except for Pacific halibut, were dominated by foreign fishers. Then, within a few years under the new management regime, the U.S. fishery largely replaced the foreign fishing fleet.

For the Bering Sea/Aleutian Islands groundfish, RAY is 1.9 million t (Table 7). The major species groups harvested are walleye pollock, Pacific cod, flatfishes, Atka mackerel, rockfish, and sablefish. Except for Greenland turbot, all flatfish species are high in abundance and in excellent condition. Walleye pollock and Pacific cod abundances are much lower than their recent high levels, but are still close to the levels that would produce LTPY.

For the Gulf of Alaska groundfish, RAY is 249,600 t. The major species groups harvested include walleye pollock, Pacific cod, sablefish, flatfishes, and slope rockfish. Overall abundance of groundfish in the Gulf has been relatively stable, except for walleye pollock, which is down.

Pacific herring stocks are producing slightly below their LTPYs. Shrimp resources are down throughout Alaska. King crab resources are depressed, but Tanner crab stocks are still relatively high.

In addition to the general groundfish

Table 4. Status of Utilization Levels of U.S. Living Marine Resources, 1992-94

Unit / Fishery	Degree of Fisheries Utilization of the Resource				
	Under	Full	Over	Unknown	Total
1. Northeast demersals	2	4	18	1	25
2. Northeast pelagics	4	1	1	0	6
3. Atlantic anadromous	0	2	3	0	5
4. Northeast invertebrates	0	3	2	1	6
5. Atlantic highly migratory pelagics	0	4	4	2	10
6. Atlantic sharks	0	1	1	1	3
7. Atlantic/Gulf of Mexico coastal migratory pelagics	1	2	1	3	7
8. Atlantic/Gulf of Mexico reef fish	0	2	10	16	28
9. Southeast drum & croaker	0	0	3	4	7
10. Southest menhaden	0	2	0	0	2
11. Southeast/Caribbean invertebrates	0	7	2	5	14
12. Pacific coast salmon	0	3	2	0	5
13. Alaska salmon	0	5	0	0	5
14. Pacific coast & Alaska pelagics	1	6	0	0	7
15. Pacific coast groundfish	5	9	3	2	19
16. W. Pacific invertebrates	0	0	1	0	1
17. W. Pacific bottomfish & armorhead	3	0	3	0	6
18. Pacific highly migratory pelagics	4	2	2	7	15
19. Alaska groundfish	10	13	0	2	25
20. Alaska shellfish	1	4	0	0	5
21. Nearshore species	3	24	7	40	74
Subtotal of Units 1-20	31	70	56	44	201
% of Subtotal	15%	35%	28%	22%	
% of 157 "known" stock groups	20%	44%	36%		
Total of Units 1-21	34	94	63	84	275
% of Total	12%	34%	23%	31%	
% of 191 "known" stock groups	18%	49%	33%		

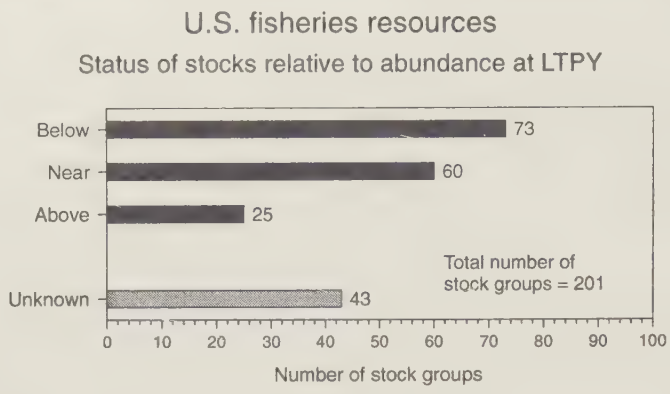


Fig. 5. Number of stock groups classified by their status of stock levels relative to abundance levels that would produce long-term potential yield for stocks under NOAA Fisheries purview.

complex, Pacific halibut is a groundfish species that has supported an important traditional fishery for both the U.S. and Canada. This resource is fully utilized and managed by the International Pacific Halibut Commission. Abundance peaked in 1989 and has been declining steadily at about 10% per year since.

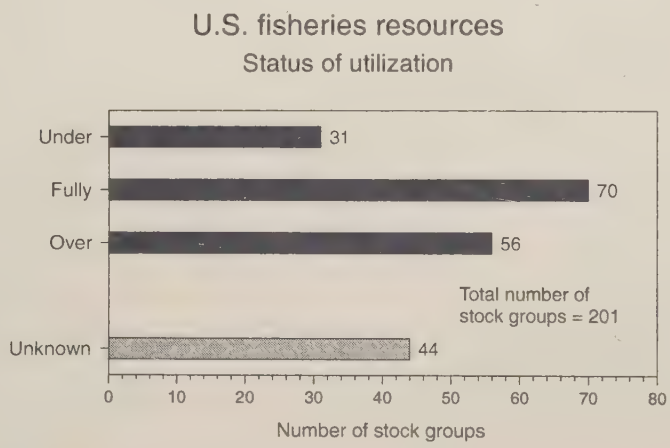


Fig. 6. Number of stock groups classified by their status of utilization for stocks under NOAA Fisheries purview.

Pacific Coast Region

The Pacific coast fisheries resources have a combined U.S. LTPY of 1.12 million t (Table 8). The major species are salmon, coastal pelagics, groundfish, Pacific halibut, and nearshore resources. The U.S. RAY is 462,800 t or only 41% of LTPY. The lower RAY is due mainly to lower abundances of coastal pelagic species (Unit 14) and groundfish (Unit 15) and underutilization of some species. Most stocks are fully utilized or overutilized.

All five species of Pacific salmon are fully or overutilized. The RAY of 23,000 t is 69% of its LTPY. Depressed production is partly due to ocean conditions that have been generally unfavorable for salmon off the Pacific coast since the late-1970s. Some stocks are depleted and have triggered ESA designations.

Coastal pelagic fishes are low in abundance, and all, except jack mackerel, are fully utilized. Jack mackerel is one of the few underutilized Pacific coast species. The RAY of 64,000 t is only 12% of LTPY. The Pacific sardine population has been increasing after decades at low abundance levels.

The groundfish fishery harvests a vast array of bottom-dwelling species from Washington to California. The RAY of 262,500 t is 56% of LTPY. The large difference between RAY and LTPY is due to a variety of factors and the diversity of this fishery complex. Some species are overexploited, some have experienced periods of low recruitment, and some are underutilized. Pacific whiting dominates the commercial catch, accounting for 72% of the groundfish catch. Rockfishes and lingcod also support popular recreational fisheries. Certain stocks, such as Pacific ocean perch, are in need of rebuilding following overutilization and a period of poor recruitment. Shortbelly rockfish is substantially underutilized.

Pacific coast shellfish resources are diverse and important both commercially and recreationally. Shrimp, crab, clams, and abalone fisheries are relatively small in terms of tonnage landed, but they contribute substantially to the value of Pacific coast fisheries due to the high prices they command. Most shellfish species are fully utilized.

Recreational fisheries are important along the Pacific coast and especially so in southern California. A wide variety of species are taken, and the recreational catch of some greatly exceeds the commercial catch. Many are nearshore resources. Gamefishes such as albacore, tuna, billfishes, rockfish, and salmon are highly prized. Recreational crabbing, clam digging, and abalone diving activities are also

significant.

Western Pacific Oceanic Region

The vast area that encompass this region stretches across the central and western Pacific Ocean and includes the Hawaiian Islands and the U.S. territories of American Samoa, Guam, and the Northern Marianas. These are tropical and subtropical island waters with a large diversity of species but relatively low sustainable yields due to limiting ocean nutrient availability. Though the magnitude of the fisheries may be relatively small (U.S. LTPY is only 283,300 t and U.S. RAY is 242,500 t, Table 9) when compared to certain larger mainland fisheries, seafood and fisheries are valued highly and important culturally and socially in Hawaii and the Pacific island territories. Additionally, certain transboundary fisheries hold considerable international interest with high collective importance and value to Pacific Rim nations and U.S. fleets fishing within and beyond the U.S. EEZ. Fishery resources include highly migratory pelagic fishes, bottomfishes, nearshore reef fishes, and invertebrates. The region also supports protected species such as the Hawaiian monk seal, green sea turtle, and blue, fin, and sperm whales.

The highly migratory stocks (tunas, billfishes, swordfish, sharks, and others) range the high seas and often occur beyond U.S. fisheries management jurisdiction. Tunas provide the major catch component and are species that migrate across multiple jurisdictions in the Pacific. The combined LTPY of these stocks throughout their migratory range is over 2.0 million t, while the prorated U.S. LTPY is only 278,900 t. Of the 15 stock groups of highly migratory pelagics, 12 stocks are near the levels that would produce their LTPYs, two are below LTPY, and one is of unknown status.

Western Pacific bottomfishes (snappers, jacks, grouper, emperors) are harvested from a variety of rock and coral habitats around Hawaii and western Pacific island territories. About 90% of the catch is taken in the main Hawaiian islands, where stock assessments indicate some important species are only at 10-30% of original stock levels, and overutilization is of concern. But when the resources are considered across the region, the U.S. LTPY of 2,700 t is seven times higher than U.S. RAY because stocks in the northwestern Hawaiian Islands, American Samoa and Marianas are underutilized.

Pelagic armorhead has been harvested by foreign fleets on the summits and slopes of submerged seamounts along the southern Emperor-northern Hawaiian Ridge since 1968. Of these undersea mountains, the only group under U.S. jurisdiction is the Hancock Seamounts, where armorhead fishing has been prohibited since 1984 to allow the stock to recover after catch rates declined to low levels. The U.S. has never fished armorhead, but because of it's fishery potential, the resource is regulated under a Seamount Groundfish FMP. This stock is currently in a recovery stage.

The most important invertebrate fisheries in the western Pacific are for spiny and slipper lobsters. They are primarily fished in the northwestern Hawaiian Islands. This fishery began in 1977 and reached its peak during the mid-1980s, but has since declined. The primary cause of the decline is thought to be a general reduction in lobster productivity and recruitment since 1989, stemming from mesoscale oceanographic changes. Since 1991, emergency closures, a limited entry regime, and a closed season was adopted to rebuild the stocks. The lobster LTPY is now much lower than during the 1983-89 period, but the stock is recovering.

Nearshore Resources

For the purposes of this report, "nearshore fishery resources" are those coastal and estuarine species under the purview of coastal states and for which NOAA Fisheries does not have direct responsibility. Many of these coastal and estuarine species provide the basis for important commercial and recreational fisheries. They vary widely in

Table 5. Productivity of Fisheries Resources of the Northeast Region, 1992-94

Productivity indicators are expressed in metric tons by long-term potential yield (LTPY), current potential yield (CPY), and recent average yield (RAY) [1]

Unit / Fishery	Entire Range of Resource			Prorated within U.S. EEZ	
	Total RAY	Total CPY	Total LTPY	U.S. RAY	U.S. LTPY
1. Northeast demersals	185,535	183,735	479,335	145,900	402,365
2. Northeast pelagics	165,800	724,300	412,000	115,600	253,920
3. Atlantic anadromous	4,836	4,836	4,836	4,836	4,836
4. Northeast invertebrates	99,500	99,900	72,500	93,568	89,357
5. Atlantic highly migratory pelagics	246,955	242,455	245,519	14,600	19,100
21. Northeast nearshore species	75,230	75,230	75,230	75,230	75,230
Northeast Total	777,856	1,330,456	1,289,420	449,734	844,808

[1] For row totals; where LTPY is unknown, CPY is substituted; where CPY is unknown, RAY is substituted. RAY is generally for the latest 3-year average, 1992-94.

species diversity and abundance. Many are highly-prized gamefish. Others are small fishes used for bait, food, and industrial products. Those of greatest interest include invertebrate species like crabs, shrimps, abalones, clams, scallops, and oysters.

Because the composition of nearshore resources is diverse and management is spread out among the many coastal states and other local authorities, a comprehensive treatment of them has not been attempted in this report. Rather than providing an in-depth review of their status, Unit 21 presents information on the more significant species and their general status.

Table 6. Productivity of Fisheries Resources of the Southeast/Gulf of Mexico/Caribbean Region, 1992-94

Productivity indicators are expressed in metric tons by long-term potential yield (LTPY), current potential yield (CPY), and recent average yield (RAY) [1]

Unit / Fishery	Entire Range of Resource			Prorated within U.S. EEZ	
	Total RAY	Total CPY	Total LTPY	U.S. RAY	U.S. LTPY
6. Atlantic sharks	9,324	9,213	10,240	9,324	10,240
7. Atlantic/Gulf of Mexico coastal migratory pelagics	17,884	20,127	26,236	17,884	26,236
8. Atlantic/Gulf of Mexico reef fish	31,225	30,750	43,158	31,225	43,158
9. Southeast drum & croaker	16,785	16,785	68,715	16,785	68,715
10. Southest menhaden	890,000	890,000	1,140,000	890,000	1,140,000
11. Southeast/Caribbean invertebrates	112,483	111,641	95,165	112,483	95,165
21. Southeast nearshore species	90,830	90,830	90,830	90,830	90,830
Southeast Total	1,168,531	1,169,346	1,474,344	1,168,531	1,474,344

[1] For row totals; where LTPY is unknown, CPY is substituted; where CPY is unknown, RAY is substituted. RAY is generally for the latest 3-year average, 1992-94.

It is difficult to assess the condition of many of the country's nearshore resources. A high percentage are of unknown status. No firm estimate exists for LTPY nor CPY. Thus, the RAY of 284,000 t (Table 1) has been used to indicate minimum amounts for CPY and LTPY. The RAY itself has been underestimated and excludes landings of large-scale nearshore fisheries like anchovy, sardine, herring, and invertebrate resources which are reported in other unit chapters.

Marine Mammals

The amended MMPA of 1994 requires the Secretary of Commerce and the Secretary of Interior to develop stock assessment reports (SARs) for all marine mammal stocks that are found within U.S. waters. NOAA Fisheries is responsible for assessing and managing 155 stocks of cetaceans and pinnipeds. The U.S. Fish and Wildlife Service has authority for stocks of North Pacific walrus, Alaska polar bear, West Indian manatee, and Alaska and California sea otters. SARs for all stocks are divided into three separate regions—Alaska, Pacific including Hawaii, and Atlantic including the Gulf of Mexico.

The MMPA requires an SAR to include, among other things, information on how the stock was defined, a minimum abundance estimate, the stock's current and maximum net productivity rate, current population trend, a calculation of PBRs, an assessment of whether incidental fishery takes are "insignificant and approaching zero mortality and serious injury rate," and an assessment whether the level of human-caused mortality and serious injury is likely to reduce the stock to below OSP or whether the stock should be classified as a "strategic stock." SARs are to be reviewed annually for strategic stocks and for stocks for which new information is available, and at least once every three years for all other stocks. The 1994 amendments also require that take reduction teams be formed for each strategic stock and charges them with developing plans to reduce takes to below the PBRs. Strategic stocks are those that are listed as endangered or threatened under the ESA or declining and likely to be listed in the foreseeable future, those designated as depleted under the MMPA (i.e., below OSP), and those for which anthropogenic mortality exceeds the estimated replacement yield.

Of the 163 marine mammal stocks managed under the MMPA, 54 are classified as strategic (Table 10). These include 4 stocks that are depleted under the MMPA, 4 that are listed as threatened and 24 as endangered under the ESA, 17 for which the total annual mortality exceeds PBR, and other stocks where information on stock status or fisheries related mortality is uncertain. In addition, 2 of 10 stocks of eastern tropical Pacific dolphin are listed as depleted under the MMPA.

With regard to population trends, of the 163 marine mammal stocks in U.S. waters, there is sufficient long-term population information to describe trends for only 55 stocks (33%), and the status of the remaining 108 stocks (66%) is unknown. Of those for which information is available, 8 (5%) are declining, 24 (15%) are known to be stable, and 23 (14%) are believed to be increasing (Table 10). The new regime

established by the 1994 MMPA amendments, once implemented by NOAA Fisheries and the USFWS, will contribute to the long-term database needed to detect and evaluate trends for all marine mammal stocks.

Sea Turtles

Six species of sea turtles regularly spend all or part of their lives off the U.S. Atlantic and Pacific coasts, and in U.S. territorial waters of the Caribbean Sea and western Pacific Ocean. Limited stock assessment data exist for about one-half of these species.

All sea turtles are listed either as endangered or threatened under the ESA (Table 10). The Kemp's ridley, hawksbill, and leatherback turtles are listed as endangered throughout their ranges. The loggerhead and olive ridley turtles are listed as threatened throughout their U.S. ranges, as is the green turtle, except the Florida nesting population which is listed as endangered.

The large Pacific population of green sea turtles at French Frigate Shoals in the Hawaiian Islands is thought to be increasing, but there is continuing concern about the tumor-associated fibropapilloma disease. Efforts continue to investigate the cause of the disease and halt its advance among green sea turtles in both Hawaiian and Florida waters.

Issues of National Concern

The management of living marine resources is complex and involves many biological, economic, social, and political factors. Each region and fishery discussed in this report, and even those fisheries that are currently well managed and yielding near their long-term potential for the national benefit, must continually adjust and adapt to ever-changing conditions. To increase long-term benefits from currently overutilized and depleted resources, the difficult issues and practices which have resulted in overutilization and resource depletion must be confronted.

In each of the 21 fishery and 4 protected species units, major issues affecting the resources and their management are raised. Although each resource unit has unique features, there are common themes that are significant to many, if not all, units. These are discussed below.

Resource Conservation and Utilization

The primary concern of fishery management is conservation—the protection and wise use of the Nation's living marine resources. Management strategies must consider which stocks are overutilized and too low to produce LTPY. Table 3 indicates that 46% of the stocks under NOAA Fisheries purview whose abundance status is known (73 out of 158 stock groups) are below the abundance levels that would produce LTPY. Similar compilations indicate that 36% of the stocks (56 out of 157 stock groups) are overutilized (Table 4).

The list of stocks that are overutilized or below the levels required to produce LTPY includes some of the our most valuable fishery resources, such as New England groundfish, Atlantic sea scallops, Gulf of Mexico shrimp, several pelagic highly migratory stocks (including Atlantic bluefin tuna and swordfish), some Pacific salmon stocks, some rockfish off Alaska, and Alaska king crab. Many nearshore stocks (including several oyster populations, bay scallops, abalones, Pacific striped bass) are also overutilized.

Green turtle
Chelonia mydas

The Northeast region has the worst case for overutilized stocks. Three historically important groundfish species (cod, haddock, and yellowtail flounder) on Georges Bank off New England are presently among the most depleted stocks in U.S. waters. Haddock and yellowtail flounder are classified as "collapsed" by virtue of their current low abundance (biomass of spawners is about 10% of the mid-1970s levels) due to prolonged excessive fishing pressure. The cod stock is in imminent danger of collapse, and portions of Georges Bank were closed to fishing beginning 1 January 1994 to reduce fishing mortality on these species and promote stock recovery.

All five species of Pacific salmon (chinook, coho, sockeye, pink, and chum), from Washington, Oregon, and California, may be considered overutilized and depleted. However, the main causes for their decline appear to be

changing ocean conditions and habitat alterations; although intense fishing pressure from competing user groups exacerbate the problem.

Most shellfish resources off Alaska are depressed and Alaska king crab is depleted in the eastern Bering Sea. Rockfish resources, particularly Pacific ocean perch, were overutilized by foreign fleets in the 1960s, but have since stabilized at historical long-term abundance levels.

In the Gulf of Mexico, the king mackerel was severely depleted because of excessively high catches in the late-1970s and early-1980s. It now supports catches about 36% of LTPY. Red snapper, traditionally the most important reef fish in the Gulf of Mexico, is taken mainly as incidental catch in the shrimp fishery, and currently supports catches only about 21% of LTPY. Red drum was subjected to intense fishing in the 1980s in response to consumer demands for "blackened redfish" and currently provides catches at about 46% of the long-term potential.

Table 7. Productivity of Fisheries Resources of the Alaska region, 1992-94

Productivity indicators are expressed in metric tons by long-term potential yield (LTPY), current potential yield (CPY), and recent average yield (RAY)[1]

Unit / Fishery	Entire Range of Resource			Prorated within U.S. EEZ	
	Total RAY	Total CPY	Total LTPY	U.S. RAY	U.S. LTPY
13. Alaska salmon	364,800	296,500	296,500	364,800	296,500
14. Alaska herring	52,900	55,200	55,200	52,900	55,200
19. Alaska groundfish					
Bering Sea/Aleutian Islands	1,902,402	3,025,385	3,483,785	1,902,402	3,483,785
Gulf of Alaska	249,582	492,240	451,440	249,582	451,440
Halibut (Alaska)	34,700	26,900	19,800	34,700	19,800
20. Alaska shellfish	125,744	125,745	113,779	125,744	113,779
21. Alaska nearshore species	3,170	3,170	3,170	3,170	3,170
Alaska Total	2,733,298	4,025,140	4,423,674	2,733,298	4,423,674

[1] For row totals; where LTPY is unknown, CPY is substituted; where CPY is unknown, RAY is substituted. RAY is generally for the latest 3-year average, 1992-94.

Other examples of overutilization can also be found throughout the country. Many are disproportionately impacted by fishing owing to their low numbers in relation to more abundant target species. In recent years, there has been growing awareness of federal actions to mitigate overutilized situations. All federal FMPs now require numerical overfishing levels to be specified according to sound population dynamics principles. Catches are normally restricted to help rebuild overfished stocks. Despite a vigilant watch for overutilization, resources do decline—some naturally, some through habitat change, and some through excessive fishing efforts—not all are controllable.

Many U.S. marine fisheries, including both the overutilized and fully utilized stocks, are overcapitalized. As generally understood, this means that there are more fishing vessels and gear trying to catch fish than are necessary to harvest the resource efficiently. Such overcapitalization is a major factor contributing to overutilization of a resource. Where fisheries are overcapitalized and performing poorly in economic terms, short-term economic concerns tend to receive undue weight relative to the steps needed to cut back harvests and achieve long-term biological and economic goals. The excess capital may maintain pressure to increase catch limits beyond potential yield levels, deplete the resource, and once depleted, prevent its recovery. Many of the other issues discussed in this report are complicated by overcapitalization. For example, excess numbers of boats exacerbate fish allocation and bycatch problems.

Economic theory and experience in most U.S. and worldwide fisheries indicate that overcapitalization is an inevitable consequence of management schemes that allow free access to fisheries. U.S. fisheries managers have recently established access controls for more fisheries. Individual transferable quota (ITQ) management plans have been approved and/or implemented for three fisheries: the Atlantic surf clam fishery, the Alaska sablefish fishery, and the Alaska Pacific halibut fishery. Additional controls on access, including ITQs, are under consideration by all FMCs.

A few abundant resources, such as some pelagic stocks in the Northeast region (Unit 2), jack mackerel off California (Unit 14), and flatfishes off Alaska (Unit 19), are currently underutilized. A much larger fishery yield can potentially be obtained from these stocks, but market conditions or bycatch limitations has kept the harvest low.

Shifting fishing pressure from overutilized to underutilized stocks may relieve pressure on stressed stocks and aid in the rebuilding of depleted stocks. However, the habitat of the stocks often overlap and effective harvesting strategies must be developed to fish one stock while not jeopardizing the other.

Bycatch

The incidental take of nontarget species in fishing operations reflects the fact

that species do not live in pure, discrete, exploitable patches, but as members of intermixing communities. Groundfish fisheries have notoriously visible bycatch problems. The fisheries, whether conducted with trawl gear, longlines, or pot gear, catch and discard large volumes of animals that are of the wrong size, wrong species, wrong maturity stage, or are otherwise unwanted. For instance, as much as 60-80% of the rock sole caught in recent years in the Bering Sea were discarded because they are not the valuable roe-bearing female fish. According to a recent United Nation's report examining bycatch amounts worldwide, 20-40% of the world's catch may have been discarded routinely.

Mitigation of bycatch problems is complex. The problem is partly biological and partly technological. While some technological innovations can work to reduce bycatch, such as the use of turtle excluder devices to minimize impacts on sea turtles in shrimp fisheries, most problems of bycatch are not as simple to resolve. In many cases, catches of high abundance species threatens low abundance species; thus the catch of more dominant species may have to be severely restricted.

Bycatch levels and control measures have occupied the attention of most fisheries management actions of all regional FMCs. Even when apparent solutions are found, the dynamics and abundance of marine species change in time and area, which can shift the character of the problems and require continuous adjustments to their solutions.

Habitat

Habitat loss and degradation affects mostly inshore and estuarine ecosystems. The primary threats come from alteration of freshwater flows, wetland loss, and destructive fishing methods. Diminution in freshwater volume and flow rates stem from damming and diversions of major rivers impacting nearshore ecosystems adapted to seasonal discharges of freshwater. Logging contributes to siltation and can destroy salmon spawning habitat upriver and impede their migratory paths.

Loss of aquatic plant-based habitat (e.g., coastal wetlands or eelgrass and kelp beds) resulting from development (e.g., marinas, docking facilities) adversely affect a variety of food webs that are important to adults and juveniles of many marine and anadromous species. Dredging and disposal of dredged material in estuaries and bays also cause significant habitat impacts.

Destructive fishing methods can also damage habitat and coral reefs. In the past, extremely damaging fishing practices that employed explosives or poisons were prevalent in some Pacific islands. These are now almost universally outlawed, but poaching by these methods remains a problem in remote regions of the western Pacific islands.

Nonindigenous Species

Many introductions of foreign (i.e., non-native) aquatic species are intentional, and made to enhance fisheries productivity or to establish organisms of cultural importance as people immigrated to new regions. However, new species may bring along undesired effects. They may compete with native species, dilute genetic integrity, or carry new diseases to the system.

The introduction of the Pacific oyster, *Crassostrea gigas*, from Japan to the U.S. Pacific coast, which now comprises much of the aquaculture production in that area, is an example of introduction that went well. Other cases are less fortunate. The discovery of nonindigenous shrimp species in South Carolina waters during the 1980s is an example of the more common consequence of accidental introductions from aquaculture sources. Pacific black tiger prawn, *Penaeus monodon*, and Pacific white shrimp, *Penaeus vannamei*, that escaped aquaculture ponds brought new diseases to the native stocks. The Pacific white shrimp, in particular, is known to sometimes harbor infectious hypodermal and hematopoietic necrosis virus and other diseases that can devastate native shrimp stocks.

While there are benefits to be gained from species introductions, the dangers of such activities are now better appreciated, and numerous regulations have been enacted to control them. In most application reviews, the risks from intentional introductions are compared to the benefits before introductions are allowed. Even so, unforeseen adverse impacts from introductions can occur.

Unintentional introductions are increasing even as intentional introductions have declined. Unintentional aquatic introductions include the release of ornamental organisms from the aquarium trade and the accidental release of cultured species. Potential problems have been

found in Florida and Hawaii where there are abundant native aquarium-trade species. Thus far, the problems has not become widespread.

Another mechanism of unintentional introduction is salmon net-pen escapes. Atlantic salmon cultured in net pens in the Atlantic Northeast and Pacific Northwest do escape and may spawn with natural salmon runs, leading to erosion of local genetic integrity. Double-mesh nets and the use of sterile animals (triploidy) are possible ways to reduce impacts of net-pen escapes.

Table 8. Productivity of Fisheries Resources of the Pacific Coast Region, 1992-94

Productivity indicators are expressed in metric tons by long-term potential yield (LTPY), current potential yield (CPY), and recent average yield (RAY) [1]

Unit / Fishery	Entire Range of Resource			Prorated within U.S. EEZ	
	Total RAY	Total CPY	Total LTPY	U.S. RAY	U.S. LTPY
12. Pacific coast salmon	22,957	33,312	33,312	22,957	33,312
14. Pacific coast pelagics	63,900	110,900	503,900	63,900	503,900
15. Pacific coast groundfish	262,657	352,491	465,750	262,657	465,750
19. Halibut (Pacific Coast)	200	300	200	200	200
21. Pacific Coast nearshore species	113,245	113,245	113,245	113,245	113,245
Pacific Coast Total	462,759	609,948	1,116,207	462,759	1,116,207

[1] For row totals; where LTPY is unknown, CPY is substituted; where CPY is unknown, RAY is substituted. RAY is generally for the latest 3-year average, 1992-94.

Nonindigenous organisms may be difficult to eradicate once they become established. The effects of introductions are impossible to predict. Slowing the spread of non-indigenous marine species and reversing the impacts of introduced species are conservation problems of growing significance.

Transboundary Jurisdiction

The fact that many living marine resources often cross the boundaries between states and with other nations complicates even the most comprehensive fisheries exploitation and management regime. Effective oversight of these species requires coordination, cooperation, and agreement among all interested parties. Stocks located largely within the waters of more than one state are, to an increasing extent, managed by interstate compacts. One example of successful interstate management is the recovery of Atlantic striped bass, highlighted in OLO '93. After striped bass was reduced to very low abundance in the 1970s, a plan was developed by the Atlantic States Marine Fisheries Commission (ASMFC) which called for a series of tight fishing restrictions during 1981-90, followed by a gradual relaxation of controls as remedial measures began to take effect. This effort culminated in a declaration in January 1995 of full stock restoration.

Stocks located primarily within federal waters are managed by plans prepared by regional FMCs and implemented and enforced by NOAA Fisheries. Stocks whose distribution overlaps the jurisdiction of more than one regional FMC require the participation of multiple FMCs.

Most stocks that extend beyond the U.S. EEZ are managed wholly or in part under international conventions. In the Atlantic, highly migratory bluefin tuna and swordfish fall under the jurisdiction of the International Commission for the Conservation of Atlantic Tunas. Regulation of these particular species is difficult since international consensus on catch levels for these high-valued fish is not always reached nor agreed on. Further, enacted measures must always be equally enforced by all nations to be effective.

Another example of a transboundary stock issue occurs on Georges Bank off New England. In 1984, a World Court decision resolving the U.S.-Canada maritime boundary dispute awarded each country part of the bank. The resulting "Hague Line" gave each country custody over the fisheries in their respective waters and the stocks distributed over the entire bank. In spite of the obvious need for joint management of important cod, haddock, pollock, yellowtail flounder, and sea scallops stocks, each country has so far exercised separate control on fisheries in their respective zones. The lack of bilateral management agreements has added to the complexity of rebuilding these overfished stocks. Recently, both countries have again taken independent actions to restrict fishing on Georges Bank.

Off the Pacific coast, anchovy and sardine straddle the border with Mexico, and several important groundfish stocks extend across the border into Canadian waters. Highly migratory tuna and billfish also cross international borders, and some range Pacific-wide. While international exchange of scientific information has been historically good, progress on joint management has been slow. In the absence of cooperative international management regimes, most stocks are regulated by individual coastal nations.

In some cases, foreign fisheries targeting migrating U.S.-origin stocks outside the U.S.

EEZ can undermine federal management of those stocks. One example is the interception of U.S. pollock stocks that occurs in the international zone of the central Bering Sea, known as the "Donut hole" area. Several international meetings were convened to address the problem, and temporary agreement was reached among all affected parties to cease fishing in the zone during 1992-95. In another positive development, an international treaty was signed and ratified in late 1995 to manage the Aleutian Basin pollock resources.

Salmon on both the Atlantic and Pacific coast begin life in freshwater and migrate to the open ocean to feed and mature before returning to their natal streams to spawn. During this period, salmon are subject to fishing pressure outside U.S. waters. Heavy exploitation of U.S.-origin Atlantic salmon in the commercial fisheries off Greenland has recently been reduced through measures implemented by the North Atlantic Salmon Conservation Organization (NASCO). Off the Pacific coast, some U.S.-origin salmon are intercepted by Canadian fishermen while migrating through Canadian waters, and some sockeye and pink salmon originating in Canada's Fraser River are caught by U.S. fishermen while transiting U.S. waters. The always-contentious allocation of expected catches from stocks originating from each country to fishermen of both nations is handled by the U.S.-Canada Pacific Salmon Commission. In the Pacific Ocean, high-seas salmon driftnet fishing is now banned under a United Nations General Assembly Resolution and by the North Pacific Anadromous Fish Commission.

Marine Mammals and Protected Species

The cumulative effects of commercial fishing activities with regard to marine mammal status are still largely unknown. One important interaction is competition for fish. Sea lions in Alaska, for example, eat juvenile pollock, while the fishing fleet target adult pollock. Thus, while direct competition is minimized, there is concern that commercial fisheries may disrupt prey availability either through bycatch of small pollock or from general disruption of the underlying food web.

The release of fish-processing waste can alter the feeding behavior of some marine animals. Sea lions and killer whales learn to feed on fish waste discharged by processing vessels and shore-based plants. This creates an artificial dependency that may not be beneficial to the long-term well being of the animals.

Direct interactions with fishing gear can be fatal to some marine mammals, but direct kills have generally been few. Other direct interactions that can interfere with normal marine mammal behavior are less well understood, but may be important in the vicinity of critical habitats and rookeries.

Of course the other side of this issue is that marine mammal competition for fishery resources may reduce fishery yields. The relationship between such predation and fishery yield is complex and difficult to quantify, but marine mammal consumption probably has a significant effect on some fisheries.

Many protected marine mammal and sea turtle stocks are listed as endangered or threatened under the ESA or depleted under the MMPA (Table 10). Developing and implementing management strategies to minimize the adverse impact of human activities on these animals and aiding their recovery, while not unnecessarily restricting commercial and recreational fisheries, is a major challenge.

Table 9. Productivity of Fisheries Resources of the Western Pacific Oceanic Region, 1992-94

Productivity indicators are expressed in metric tons by long-term potential yield (LTPY), current potential yield (CPY), and recent average yield (RAY) [1]

Unit / Fishery	Entire Range of Resource			Prorated within U.S. EEZ	
	Total RAY	Total CPY	Total LTPY	U.S. RAY	U.S. LTPY
16. W. Pacific invertebrates	143	106	135	143	135
17. W. Pacific bottomfish & armorhead	388	626	2,738	388	2,738
18. Pacific highly migratory pelagics	2,077,232	2,003,188	2,033,706	240,438	278,945
21. W. Pacific nearshore species	1,520	1,520	1,520	1,520	1,520
Western Pacific Total	2,079,283	2,005,440	2,038,099	242,489	283,338

[1] For row totals; where LTPY is unknown, CPY is substituted; where CPY is unknown, RAY is substituted. RAY is generally for the latest 3-year average, 1992-94.

Contaminants

Toxic contaminants in estuarine and marine habitats originate from a variety of sources, including industrial and sewage treatment plants, urban and agricultural runoff, and air pollution. These contaminants include toxic metals and such organic chemicals as chlorinated hydrocarbons and petroleum compounds.

Elevated concentrations of these contami-

nants can be found in bottomfish and shellfish from a number of urban and industrialized sites in many coastal areas. For example, bottomfish species from a number of chemically contaminated areas in the vicinity of such major cities as Boston, New York, Los Angeles, and Seattle exhibit liver cancers and other lesions that are associated with the process that leads to liver cancer. While cancers are the most dramatic of the lesions observed, early degenerative or proliferative conditions are much more prevalent and are found in animals from moderately as well as heavily contaminated sites. Others may suffer various types of reproductive impairment such as inhibited spawning ability and reduced viability of eggs and larvae.

Little is known about contaminant effects on marine mammals, although studies continue on the effects of DichloroDiphenylTrichloroethane (DDT) and Polychlorinated Biphenyls (PCBs) on California sea lions. Toxic effects range from sublethal changes, such as slower growth, to death.

There is also widespread public concern about large oil spills in the marine environment. A large spill can cause extensive loss of plants and wildlife, commercial and recreational uses, and property values. The 1989 *Exxon Valdez* oil spill in Prince William Sound, Alaska, is a recent example.

Chemicals, microbial pathogens, and marine toxins are potential contaminants to seafood. In most U.S. coastal areas, the human health risks projected from current levels of marine environmental contamination in marine seafood products are either negligible or undetectable. However, fish and shellfish from some areas, such as near Boston Harbor and San Pedro Bay near Los Angeles, have been known to contain elevated levels of toxic chemicals that could be potentially harmful to human health.

Another major type of pollution, discharges of infectious microorganisms from agricultural and domestic sources, can contaminate clams, oysters, and other shellfish species. This potential risk to humans has resulted in the closing of vast coastal waters to shellfish aquaculture and harvesting; however, with present management practices, the risk remains relatively low.

Marine biotoxins, such as paralytic shellfish poisoning (PSP) and domoic acid or amnesiac shellfish poisoning (ASP) adversely affect fisheries by jeopardizing the safety of some of their products. PSP results from the consumption of molluscs infected with specific strains of dinoflagellates. Domoic acid outbreaks have occurred in a variety of seafood products and caused huge losses to the seafood industry. For example, in the fall of 1991, an outbreak of domoic acid poisoning in Monterey Bay, California, moved up the coast and to Oregon and Washington. Like PSP, the primary route of human exposure to domoic acid is from eating affected molluscs (e.g., razor clams), although the viscera of Dungeness crab is also known to accumulate high levels of the acid. The mechanism by which the acid is accumulated is not clear. Biotoxins occur naturally, but the apparent increase in their occurrence may be related to coastal development, including nutrient enrichment.

Table 10. Status and Trends of Marine Mammals and Sea Turtles

Unit	Decreasing	Stable	Increasing	Unknown	Total	Strategic Status	MMPA / ESA Status[1] E, T, D
22. Alaska Region	2	10	5	18	35	9	6,2,1
23. Pacific Region	4	13	13	36	66	16	9,2,2
24. Atlantic Region	2	1	5	54	62	29	9,0,1
% of Total	5%	15%	14%	66%	163		
25. Sea Turtles[2]	2	2	2	4	10		7,3,0

[1] E = Endangered, T = Threatened, D = Depleted
[2] Five stocks of sea turtles from the Pacific side and five from the Atlantic side.

Marine Debris

Marine debris pollutes all of the world's oceans, but the problem hardly begins there. Close to 80% of the debris is washed, blown, or dumped from shore. This debris casts a broad shadow over marine and littoral animals, plants, and perhaps even entire ecosystems. Biological studies tell us that waterborne litter entangles wildlife and masquerades as a food source, smothers beaches and bottom-growing plants, and provides a surface for colonizing small organisms that travel on marine debris to distant shores, perhaps with adverse ecological consequences. Entanglement is the most obvious of all biological impacts. Northern fur seals entangled in net webbing were spotted as early as the 1930s. Only fleeting glimpses of entangled animals are possible from planes and ships. Many die and sink or are eaten by predators without detection; others remain submerged and hidden beneath the ocean surface. At least 135 species of marine vertebrates and eight invertebrates have been reported entangled in marine debris. The list now includes most of the world's sea turtle species and more than 25% of marine mammal

species.

Ingestion of some marine debris can be a serious threat. Sea turtles mistake clear plastic bags for jellyfish, a favorite natural food. Ingested debris damages the digestive tract, causes starvation by blocking food, may be toxic, and in general is a serious source of mortality.

For centuries, we have used the oceans as dumping grounds for waste. Trash was simply heaved overboard from ships; much of it still is. At present, two global conventions combat marine debris pollution from sea-based sources: the London Dumping Convention (LDC) and the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). Land-based sources of marine pollution are beginning to be addressed globally in follow-up meetings to the 1992 U.N. Conference on Environment and Development. The U.S. is party to these fora and takes an active role in mitigating marine debris problems. Education and promotion of awareness of the issue and its many solutions seem the best ways to combat this widespread phenomenon.

Adequacy of Scientific Information and Assessments

The status of fishery resources has been classified as unknown for 34% of the stocks covered in OLO '95. Most are nearshore resources (50 out of 74 nearshore stock groups). The figure may give an overly negative impression of our knowledge of national LMRs. However, they accounted for only 4.7% of U.S. RAY (238,000 t out of 5.06 million t) during 1992-94. In turn, this means that the status is known for the stocks that produce more than 95% of the U.S. catch.

But sound, scientifically based fisheries management requires more than the ability to classify the status of stocks. Relatively precise estimates of actual abundance, fishing mortality, and potential yield (e.g., CPY and LTPY) are more desirable. To improve on these estimates, more effective research and data sets will be needed.

Many potential benefits from LMRs may not be achieved because of insufficient data. When the status of LMRs is unknown or imprecisely known, it is necessary to harvest more conservatively to guard against accidental depletion. Some groundfish fisheries in the eastern Bering Sea and Gulf of Alaska (Unit 19) are examples of such a cautious strategy. On the other hand, the lack of precision in assessments of fishery resources has rather unfortunately been used in some cases to argue that the evidence of overutilization was not strong enough to justify restricting a fishery. This argument has led to the depletion of many historically abundant stocks (e.g., most of the historical New England groundfish and flounder stocks represented in Unit 1).

Uncertainty about the relationship between marine mammals and fisheries now threatens both. In the example of Steller sea lions off Alaska, the sea lion population has declined substantially and the scientific basis to determine if the fishery is negatively impacting them remains incomplete.

It is also important to note that the status of stocks is unknown for 65% (112 out of 173 stock groups) of the marine mammal and sea turtle groups reported here. Trend data are similarly lacking.

In addition to uncertainties in the status of stocks and abundance estimates or trends, there are critical gaps in our knowledge about ecosystem effects on LMRs. These gaps include the effects of environmental variability and change; including climate, functional habitat alteration, and long-term environmental degradation. Also included are gaps in knowledge about multispecies interactions.

Outlook

The ocean environment is particularly complex. Such factors as wide temperature fluctuations, frequent storm events, and global ocean warming, to name a few, combine to create a highly variable environment that affects resource populations. What is lacking is good information and scientific knowledge on the quantitative interrelationships of the major species and the components of marine ecosystems.

A wide range of human activities affect LMRs. Ever-intensifying fishing efforts and deployment of more powerful and sophisticated fishing gear and electronic fish-finding equipment have resulted in gross overfishing of some resources. Associated with fishing is "bycatch," the situation in which nontarget species are taken in fishing operations. These problems have caused management to move toward "controlled access" to fishing whereby catch quotas would be allocated to individual fishing vessels instead of granting free and open access to all vessels. This move towards the allocation

of quota share to individual vessels is gradually achieving wider acceptance by both managers and fishermen.

Today, another major issue is mitigation to protect endangered or threatened species. The use of riverine waters for irrigation, power generation, and consumptive uses by large urban areas has compromised freshwater flows and the survival of Pacific salmon runs. The people and the courts have become more involved with mitigation of the issues, and some rather extreme options, as in the case of the removal of the two Elwha River Dams on the Olympic Peninsula of Washington State, are being contemplated.

Urbanization has led to habitat alterations in rivers, estuaries, as well as coastal zones. Along with urbanization has come alteration of freshwater flows, erosion, introduction of toxic chemicals and other contaminants into the waters, introduction of nonindigenous species, and degradation of the marine habitats essential to the survival of LMRs.

Many demographic trends suggest that these conditions and threats are not likely to change in the immediate future. Some 50% of the U.S. population reportedly lives within a 2- or 3-hour drive of major freshwater systems (the Great Lakes) or the coastal ocean. As the national economy grows, there will be further development at the land-sea interface. The human desire to live within sight of the ocean has never abated and, increasingly, urban dwelling areas are being developed on or near the shorelines.

There are also many natural changes in the dynamics of the ecosystem that may exacerbate the aforementioned issues. For instance, global warming research over the past two decades now shows widespread impacts on living marine resources. Articles in recent issues of major scientific publications such as *Science*, indicate subtle yet progressive warming of Pacific coastal waters and consequently an eradication of certain species that would have been found in these waters a half-century ago. The foregoing suggests that it is necessary to have a far better understanding of how human activities, in concert with short- and long-term climatic changes, can compromise LMR viability.

Thus far, the utilization and management of the Nation's LMRs have been approached mainly from a resource-by-resource point of view. As information on multispecies relationships, ecosystem interactions, and environmental influences becomes more available, management approaches can move toward more explicit considerations of human activities on all components of the ecosystem. The goal is to move toward utilization of living marine resources for their combined ecological, recreational, commercial, and other aesthetic values. These optimal values and uses are no simple matter to define, let alone achieve. Thus the task will remain a formidable challenge for the fisheries, scientists and managers.

Generally, the outlook for the welfare of the Nation's LMRs is "guarded" with a need to remain vigilant. The unprecedented decline in the Northeast groundfish fisheries, the precarious state of some Pacific Northwest salmon stocks, and declines in some marine mammal populations are situations that need special attention. While many of our marine resources remain in good condition, they must be attentively managed and conserved under a suite of federal laws and international treaties. The science of the marine environment and the resources found there must be improved, because without reliable scientific knowledge, resource utilization and management must continue in a very conservative and narrow scope. ❑

Pacific Northwest Salmon

PINK • CHUM • CHINOOK • COHO • SOCKEYE

Introduction

This article describes the biology, history and development of Pacific Northwest salmon and their fisheries, and identifies issues of special concern that have caused some of the salmon stocks to be listed under the Endangered Species Act. The status of Pacific coast salmon stocks are described in Unit 12; Alaska salmon stocks are considered in Unit 13.

Salmon have played an important role in the culture and commerce of the Pacific Northwest since time immemorial. Six species are traditionally called Pacific salmon: Chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), and the cherry or masou salmon (*O. masou*). All but the Asian cherry salmon are found in the northeast Pacific Ocean and spawn in rivers of the Pacific Northwest. All Pacific salmon spawn only once in their lives, and all species are considered to be anadromous, i.e., they migrate from saltwater to freshwater to spawn. The catch history for each species is shown in Figures 7 to 11.

Pink Salmon

The pink salmon has the smallest body size of all North American Pacific salmon, averaging 1.0 to 2.5 kg at maturity. Pink salmon are sometimes called "humpback" salmon or "humpies" because the males develop a large dorsal hump at maturity. It is the most abundant species of Pacific salmon and the least dependent on freshwater. Thus, depending on whether Pacific salmon evolved from a freshwater or marine ancestor, pink salmon may be considered either the most primitive or the most highly evolved species.

Pink salmon commonly spawn around the north Pacific Rim from North Korea to Puget Sound, Washington. Spawning has been reported as far south as Monterey Bay, California, but the southernmost runs regularly occur in Puget Sound. Most pink salmon spawn in the lower sections of coastal rivers and creeks, though some spawn in brackish water. The young salmon or fry migrate to sea immediately after emerging from their gravel beds and, during extensive offshore North Pacific migrations, grow to full size and return to spawn at age 2.

Because of this rigid two-year life cycle, populations that spawn in even years and odd years are reproductively isolated even if they spawn in the same stream. In fact, odd-year pink salmon in North America are more closely related to odd-year pink salmon in Asia than to even-year pink salmon that spawn in the same North American streams. In Puget Sound and southern British Columbia, most pink salmon spawn in odd years.

Chum Salmon

Chum salmon, also called dog salmon, is the second most abundant and the second largest Pacific salmon at maturity, averaging 4.6 kg. Like pink salmon, chum salmon spend little time in freshwater. Most adults enter freshwater when they are fully mature and spawn and die within a few days of freshwater entry. Also like pink salmon, chum salmon usually spawn in the lower reaches of rivers and rarely ascend streams above any barriers that require leaping, although some in the Yukon River (Alaska/Canada) migrate over 2,000 km upstream to spawn. Chum salmon juveniles also migrate to sea immediately after emerging from the gravel and undertake extensive oceanic migrations. However, unlike pink salmon, chum salmon do not always mature at the same age: a few mature at age 2, some at age 3, but in the Pacific Northwest, most mature at age 4.

Chinook Salmon

Chinook or king salmon is the least abundant species of Pacific Northwest salmon and has the largest body size at maturity, with fish as large as 57 kg (126 lb). The species has two distinct life history patterns which are characterized as "stream-type" or "ocean-type" rearing.

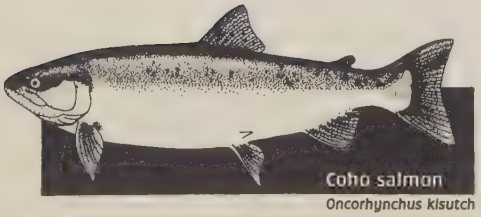
Adult stream-type chinook salmon tend to enter freshwater in the spring or summer when they are still bright silver in color and not fully mature. They typically migrate to headwater areas and hold in pools until the fall when they spawn. Juveniles predominantly remain in freshwater for one or more years before migrating to the sea. At sea, the stream-type chinooks make extensive high-seas migrations.

Ocean-type chinook salmon tend to spawn in the larger mainstem rivers at lower elevations than stream-type fish. Adults generally enter freshwater in the fall and spawn within a month or two of freshwater entry. Ocean-type juveniles rear in freshwater or estuaries for a few months after emergence from the gravel and then migrate to sea as subyearlings. At sea they tend to remain in the area of the continental shelf where they are more vulnerable to shore-based fisheries.

Because of the great differences in their life histories, freshwater habitat has a much larger influence on the survival of stream-type chinook salmon than on that of ocean-type chinook salmon. Stream-type chinook salmon are also less suitable for hatchery rearing because the extended freshwater holding periods of both adults and juveniles require extensive facilities. Consequently, stream-type fish, which was once the dominant life-history type in Washington, Oregon, and California, has declined far more than ocean-type chinook salmon in the region.

Coho Salmon

Coho salmon has a less diverse life history than chinook salmon, and it is more dependent on freshwater habitat than ocean-type chinooks. In the southern part of its range, juveniles spend their first year in freshwater before migrating to sea. In more northerly areas, they may spend 2 years in freshwater. Like ocean-type chinook, coho salmon tend to remain relatively close to shore, where they are harvested in commercial and recreational troll fisheries.



Oncorhynchus kisutch

A small percentage of the fish, mostly males, return to spawn at age 2 after spending one summer in the ocean, but the majority of coho mature at age 3. Coho salmon tends to spawn in the headwater areas of streams that are smaller than those used by chinook salmon, and coho juveniles rear for their first year in backwaters and side channels before migrating to sea as yearlings. Erosion and sedimentation resulting from logging has degraded much of the coho salmon spawning habitat, and channelization of coastal streams for agriculture and flood control has severely reduced the available rearing habitat of coho salmon in many areas.

Sockeye Salmon

Sockeye salmon has the most complex life history of North American Pacific salmon. The species usually spawns in river systems that contain lakes. Runs of sockeye salmon in a single river system can include separate races that spawn upstream and downstream from a lake, as well as beach spawners that spawn within the lake itself. There are also resident populations of sockeye, known as kokanee, that never migrate to sea.

After hatching and emerging from the gravel, sockeye fry migrate to lake waters where they live from 1 to 3 years before migrating to sea. The fish mature after spending from 1 to 5 years in the ocean.

At maturity, the male sockeye salmon develops a pronounced dorsal hump and an exaggerated hooked jaw, and both sexes turn bright red with a green head. In North America, the sockeye salmon is the third most abundant Pacific salmon species, after pink and chum salmon. However, the sockeye salmon is the least abundant salmon species in the Pacific Northwest, as its largest populations are found in Canada and Alaska.

History

Salmon played a central role in the culture of Indian tribes of the Pacific Northwest prior to the arrival of Europeans. Its abundance, as well as that of other fish and game, permitted a human population density that was unequaled elsewhere in North America. The reliability of runs and the relative ease of capture of migrating salmon permitted a degree of affluence among tribes of the Pacific Northwest, which is amply reflected in their art, commerce, and culture.

The early Indians used hook and line, traps, weirs, jigs, spears, and a variety of nets to harvest salmon. Large river systems like the Sacramento, Columbia, and Fraser had many salmon runs returning at different times. Conse-

quently, salmon were available for harvest nearly year round.

Within Puget Sound, the coastal Salish people developed a fishing method called reef netting that targeted Fraser River sockeye salmon on their homeward migration. This method involved guiding the migrating salmon over a net suspended between two canoes and then raising the net. Reef netting was labor-intensive but highly productive, and is still in limited use today.

In 1855 and 1856, the U.S. Government negotiated treaties with native tribes in the Pacific Northwest when land was opened for new settlement. In these treaties, Indians were guaranteed the right "to fish in common" at their traditional fishing locations with the non-native settlers.

When the early Europeans arrived on the west coast of North America, they also began to harvest salmon for subsistence and limited commerce at local markets as fresh fish and for export as salted and dried fish. In 1864, the Hume brothers started a salmon cannery on the Sacramento River in California. Three years later, they opened their first cannery on the Columbia River, and the commercial salmon fishery rapidly expanded.

Early canning production focused entirely on chinook salmon. Chinook catches peaked on the Columbia River in 1883 when 630,000 cases of salmon, representing nearly 20,000 t of fish, were packed. The salmon were caught in freshwater with weirs, traps, fish wheels, seines, and gillnets. As the chinook runs began to decline, the industry also targeted other Pacific salmon species. Total harvest peaked in 1911 when about 22,500 t of salmon were taken from the Columbia River. Nearly every accessible river in California, Oregon, and Washington with a significant run of salmon had at least one cannery on it.

In Puget Sound, the canning industry targeted sockeye salmon from the Fraser River in Canada. Salmon migration routes brought a significant portion of Fraser River fish through U.S. waters in the San Juan Islands and in the waters off Point Roberts at the U.S.-Canada border. The canneries initially obtained a large part of their fish from the Indian reef-net fishery, but as more efficient gear was introduced, the Indians were almost completely displaced from the commercial fishery.

In the 1890s, traditional reef-net sites were taken over by fish traps, which were often owned by the canneries and were much more efficient than the traditional Indian gear. Gillnetters and purse seiners began to harvest fish before they reached the traps. When boats became motorized in the early part of the 20th century, they were able to fish the runs as they entered the Strait of Juan de Fuca, and to follow the runs through Puget Sound.

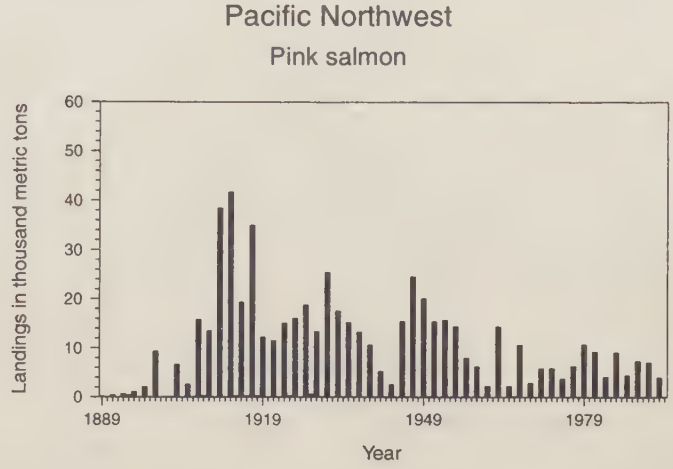


Fig. 7. Historical landings of pink salmon.

At that time, the Indians lacked the financial resources necessary to enter these capital-intensive fisheries and mostly were restricted to subsistence fishing near river mouths on reservation land. In the early-1900s, concern arose over declining salmon abundance, and the states began to restrict salmon fishing seasons. The ocean troll fishery rapidly expanded thereafter for a number of reasons: the introduction of powerboats made the offshore fishery feasible, gear was relatively inexpensive, and the fishery was initially exempt from license requirements and closed seasons because it operated outside state jurisdiction.

With the additional gear types and participants, salmon runs continued to decline. States began to pass further restrictions on fishing, but many restrictions were aimed more at allocation than at conservation.

In the 1930s, Washington and Oregon banned fixed gear, such as fishwheels and traps, for salmon. Most fishwheels and traps were owned by canneries, and the less efficient gillnet and recreational fisheries had more public support than the cannery operators. Since then, there has been a trend to eliminate more

efficient gear types and to allow expansion of effort in the remaining fisheries. California eliminated all non-tribal salmon gillnetting in the 1950s, and Oregon did the same in state coastal rivers. Presently, the only legal gear in the ocean salmon fisheries is hook and line, but gillnetting is still permitted in the Columbia River and by Indian tribes in estuaries and fresh water. Purse seining, gillnetting, and reef netting are all permitted in Puget Sound.

In 1974, a federal court presided over by Judge George Boldt ruled that the treaty phrase "to fish in common" entitled the treaty tribes to half of the available harvest from salmon stocks that passed through traditional Indian fishing grounds. The State of Washington had argued that when it had become a state, its authority to manage fisheries and commerce within its boundaries superseded Indian treaties negotiated by the federal government when Washington was a territory. The Court also ruled that tribal fishing rights had precedence over any other salmon fishing privileges that all others had.

The Boldt decision mandated reallocation of a major portion of the salmon resource and thus a subsequent downsizing of the non-Indian commercial fishery. Since 1974, treaty tribes in the Pacific Northwest have been allocated an increasing share of the salmon resource and have assumed a significant role in management of the stocks.

As Pacific Coast settlement progressed, freshwater salmon habitat has been lost. In California, sedimentation caused by hydraulic mining in the mid-1800s nearly extirpated salmon runs in the American, Feather, and Trinity Rivers. Throughout California, Oregon, and Washington, logging, flood control projects, and diversion of water for agriculture reduced the amount of available habitat and degraded much of what was left. On the Fraser River in British Columbia, rockslides and debris from railroad construction caused a blockage of the river at Hells Gate that prevented most fish passage in 1914 and contributed to the decline of upper Fraser River populations. From the early-1900s through the 1960s, construction of dams for hydropower, irrigation, and flood control continued to progressively block fish passage and reduce salmon habitat despite requirements that the larger dam projects include construction and operation of hatcheries as mitigation for their impacts on salmon.

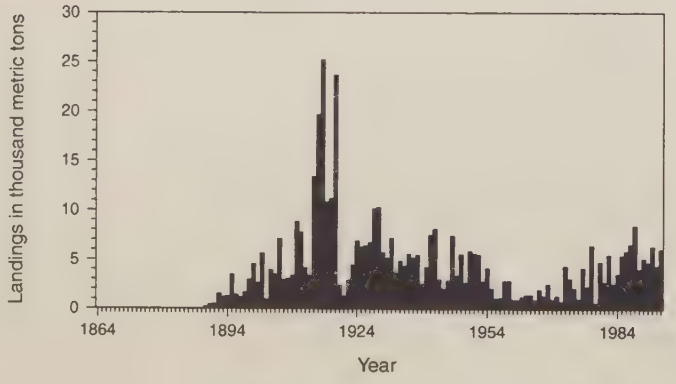


Fig. 8. Historical landings of chum salmon.

Present Fisheries

Recreational

Currently, recreational salmon fisheries operate in freshwater, saltwater, and in estuaries: all are restricted to hook-and-line gear and target primarily chinook and coho salmon. Recreational fisheries in state waters are managed by the states, while those in the ocean are managed by the Pacific Fishery Management Council.

In the ocean and Puget Sound, anglers fish from private skiffs and commercial passenger fishing vessels by either trolling or drifting with bait. In California, most fish taken in the ocean recreational fishery are chinook salmon. In Oregon and Washington, coho salmon are usually targeted, but in all three states, both species are taken whenever regulations allow. Within Puget Sound, some pink salmon are taken by trolling in the recreational fishery, and a chum salmon fishery has developed in recent years that is primarily catch-and-release using light tackle or flies. In freshwater, most recreational fishing is done from boats or river banks using light tackle.

Commercial

Non-tribal commercial fisheries remain offshore, in Puget Sound, and in the Columbia River. In the ocean, all fish are taken by trolling with hook-and-line. A commercial salmon troller typically uses 6 wire lines with up to 6 "spreads" or pieces of terminal gear on each line for a total of 36 lures fishing simultaneously. In recent

years, ocean regulations have been adopted restricting the number of spreads on each line in an effort to make the commercial fisheries more selective. Commercial troll fisheries target chinook and coho salmon, though they take a few pink salmon incidentally.

Most troll catches are marketed as premium fresh or frozen products, as the fish taken in saltwater are bright silver and unmarked by nets. In Puget Sound, commercial fishing is conducted with gillnets and purse seines, in addition to troll gear. The fleets target Fraser River sockeye and pink salmon runs, which tend to school during their return migration, making them more vulnerable to net gear. Some also target hatchery-reared coho salmon runs that have earlier run timing than the natural spawning populations of coho. They also take large numbers of Puget Sound pink salmon in odd years and any other salmon that are encountered.

Tribal

In Puget Sound and off coastal Washington, many treaty tribes engage in commercial, ceremonial, and subsistence salmon fishing. Tribal commercial fisheries use the same gear types as non-tribal commercial fisheries, and, though primarily commercial, some fish are kept for personal use. Tribes also operate fisheries in estuaries and in freshwater, targeting salmon and steelhead (the sea-run form of rainbow trout). The majority of these fisheries use gillnets, although dip nets and weirs also still are used. As a general rule, fish taken in freshwater are used for subsistence and ceremonial purposes, though harvest in excess of subsistence needs is often sold.

In the Puget Sound area and on the coast of Washington, many treaty tribes participate in the fishery management process through the Northwest Indian Fisheries Commission. On the Columbia River four treaty tribes belong to the Columbia River Inter-Tribal Fish Commission. The decline and loss of many upper Columbia River salmon stocks have made it difficult for upriver tribes to receive their allotted share of the harvest.

In California, three tribes fish the Klamath River basin: The Yuroks harvest salmon in the Klamath River estuary with gillnets, the Hoopa Valley Tribe operates a subsistence gillnet fishery in the Trinity River (a Klamath tributary), and the Karuks have a subsistence dipnet fishery at Ishi Pishi falls on the mainstem Klamath River. These tribes differ from the treaty tribes of Washington and Oregon in that no treaty was ever negotiated with the U.S. Government that guaranteed them perpetual fishing rights.

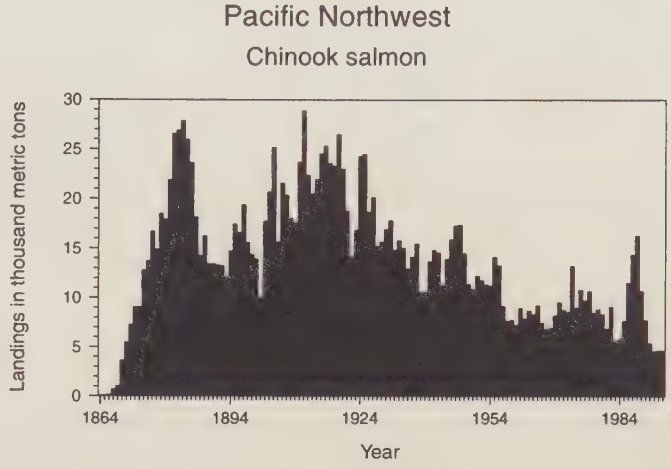


Fig. 9. Historical landings of chinook salmon.

Management

Pacific salmon management involves several national and international jurisdictions. In 1955, the International North Pacific Fish Commission (INPFC) was established by convention by the United States, Japan, and Canada to develop agreements for harvesting and conserving Pacific salmon on the high seas. INPFC sponsored extensive research programs to determine ocean distribution and migration pathways of all species of Pacific salmon and made recommendations on high-seas salmon fishing. Research sponsored by the INPFC included pioneering work on tagging, scale pattern analysis, genetic stock identification, and parasite analysis. The organization was dissolved in 1993 and its obligation was assumed by the North Pacific Anadromous Fish Commission (NPAFC). The NPAFC has four members: the three original INPFC nations and Russia.

The International Pacific Salmon Fisheries Commission was established in 1936 by treaty between the U.S. and Canada to allocate harvest of Fraser River fish and to restore stocks of sockeye and pink salmon in the Fraser River. In 1985, this organization was replaced by the Pacific Salmon Commission (PSC) as estab-

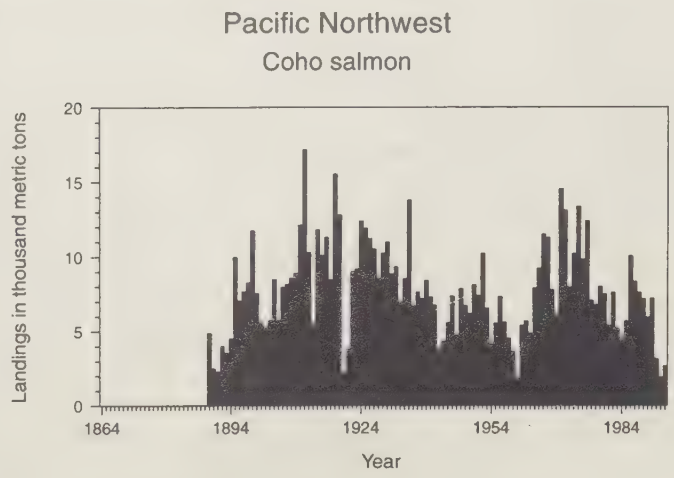


Fig. 10. Historical landings of coho salmon.

lished by the U.S.-Canada Pacific Salmon Treaty. The PSC, through its Fraser River Panel, manages sockeye and pink salmon fisheries in treaty waters and allocates harvest as jointly agreed. The PSC also has the authority for in-season regulation of salmon fisheries within treaty areas based on information collected during the season.

In Washington, Oregon, and California, ocean salmon fisheries are managed by the Pacific Fishery Management Council under a framework management plan. Each year, the Council reviews the status of key stocks and evaluates management recommendations. The Council adopts recommendations for ocean fisheries seasons and submits them to the U.S. Secretary of Commerce for approval. NOAA Fisheries implements ocean fishing regulations and, with Council advice, provides in-season management. States and tribes monitor landings in the commercial and recreational fisheries, but the U.S. Coast Guard and NOAA Fisheries are also involved in enforcement.

Issues of Concern

Allocation

Pacific salmon fisheries are managed to meet annual spawning escapement goals. Each year, a forecast is made for most stocks and, given expected abundance levels and legally mandated tribal allocations, a set of fishery openings and quotas is designed to meet escapement goals for the most critical stocks.

Disputes over allocation of harvest have been common between gear types within the commercial fisheries, between commercial and recreational fishing interests, between states, and between tribal and non-tribal fisheries. While most allocation issues are addressed through the management process, disputes over tribal and non-tribal allocation have been negotiated or resolved primarily outside of the management arena, in the courts.

The current fishery management structure operates under the MFCMA which was passed after the 1974 Boldt decision had allocated 50% of the harvest to treaty tribes in Washington. Implementing this allocation has been difficult because most tribal fisheries have traditionally operated in terminal areas (i.e., in rivers and estuaries) making tribal fishermen the last in line to physically harvest salmon. For salmon to reach tribal fisheries, they must first escape all the preterminal fisheries.

Prior to the Boldt decision, preterminal fisheries were harvesting salmon at rates that probably exceeded the harvest rates necessary to achieve the long-term potential yield, and they still have the capacity to overexploit all salmon stocks. To reduce the ocean harvest enough to allow terminal fisheries 50% of the total harvest, pre-terminal fisheries had to reduce fishing by more than 50%. This has required profound reductions in non-tribal fishing fleets.

In Puget Sound, the State of Washington and the tribes have undertaken a number of programs to minimize impacts on preterminal fisheries. Large hatchery programs were developed to increase coho salmon production and the number of fish available for harvest, and fishery openings were provided exclusively for tribal fishing. Hatchery programs have selected broodstocks with early run timing to allow fisheries to target hatchery fish while avoiding naturally produced fish. This policy is also intended to minimize the impacts of hatchery straying on natural populations of coho salmon. In the southern part of Puget Sound and Hood Canal, coho salmon are reared for an extended period in saltwater net-pens prior to release in an attempt to keep fish near terminal areas to enhance recreational and tribal fisheries.

Tribes on the Klamath River in California were not included in the Boldt decision because the Hoopa Valley reservation originally was established by presidential order rather than by treaty. Consequently, there was no treaty language guaranteeing tribal fishing rights on the

Klamath River. California banned gillnetting in freshwater in 1956 and asserted that the state had the authority to regulate fisheries on Indian reservations. It was not until 1979 that a federal court recognized the right of Indians to fish commercially on reservations in the Klamath basin. However, the court decision did not specify tribal allocations.

The lack of agreement over tribal allocations in the Klamath basin has complicated the management of ocean salmon fisheries in southern Oregon and northern California. In 1992, the Yurok tribe argued that because they had surrendered no aboriginal rights by signing a treaty, they were entitled to at least as large a share of the harvest as treaty tribes. In 1993, the U.S. Departments of Commerce and Interior issued a legal opinion supporting the Yurok claim, and ocean salmon fisheries in southern Oregon and northern California have subsequently managed to provide a 50% allocation of Klamath River chinook salmon to the tribes.

Habitat

Habitat degradation and loss is a constant threat to salmon survival and persistence. The impacts generally increase from north to south and have affected each species of Pacific salmon in proportion to its dependence on freshwater habitat. Toward the southern end of the Pacific salmon range, impacts have been the greatest. In California's central valley, which once contained over 6,000 miles of salmon spawning and rearing habitat. Because of dam construction for flood control, hydropower, and irrigation, less than 200 miles of habitat remain today, and the remaining habitat continues to decline in quality. Dams have interrupted the movement of gravel downstream, so as floods wash spawning gravel downstream, it is not replaced by new gravel from upstream. The construction of levees to reduce flooding has also reduced contributions of spawning gravel from stream banks which once resulted from shifts in the river's channel. Bank protection programs have eliminated much of the shaded nearshore habitat where young salmon once reared, and irrigation diversions entrain fish into agricultural fields and canals.

In the coastal rivers of northern California and Oregon, logging and agriculture have had several detrimental impacts on salmon. Logging has increased sedimentation in coastal streams, filling in pools and increasing the proportion of fine sediments in spawning gravel, which can suffocate incubating eggs. Past logging practices did not leave buffer strips of timber along streams to provide shaded habitat and large woody debris. Shaded habitat maintains lower water temperatures and large woody debris plays an important role in pool formation in smaller streams where coho salmon live. In lower portions of coastal streams, river bottoms have been channeled to reclaim the floodplains for agriculture and grazing. This has greatly reduced the meandering of streams which used to produce the side channels and backwater areas utilized by young coho salmon.

In the Columbia River basin, development of hydropower resources has entailed construction of 11 dams on the mainstem Columbia River and several more on the Snake River. Fish passage facilities were provided on most dams for adult fish migrating upstream to spawn, and fish guidance and bypass structures were added to pass downstream migrants around the turbines. However, the fish passage facilities have been less effective than anticipated and are still being refined.

Reservoirs created by hydroelectric dams inundated most mainstem spawning habitat, and impassable dams cut off headwater areas that historically contained many miles of spawning habitat. Impounded reservoirs also created habitat for salmon predators and increased the time that it takes smolts to complete their downstream migration. To improve survival of juvenile fish on their downstream migration, NOAA Fisheries and the U.S. Army Corps of Engineers instituted a transportation program whereby smolts are collected at the upper dams and loaded onto barges for transportation past all downstream reservoirs and dams. While this program has been successful in improving the survival of downstream migrants, the abundance of several upper basin runs of salmon has not increased.

On the Olympic Peninsula of Washington, the headwaters of most rivers lie inside the Olympic National Park, where they are protected and remain in relatively pristine condition. However, the lowlands through which these rivers flow fall outside the park and have been extensively logged with concurrent habitat degradation. Particularly noteworthy is the Elwha River, which was once one of the largest producers of salmon on the Olympic Peninsula. It was unique in that it supported all five species of Pacific salmon, in addition to steelhead (*O. mykiss*), coastal cutthroat trout (*O. clarki*), and

the Dolly Varden (*Salvelinus malma*) and bull trout (*S. confluentus*). The chinook salmon produced by the Elwha River were the largest salmonids on the Olympic Peninsula with fish reportedly taken that were over 45 kg.

From 1910 to 1912, a dam was constructed for hydropower 8 km from the mouth of the Elwha, and no provisions were made for fish passage. In 1927, a second impassable dam was constructed 14 km above the first one. Thus, for over 80 years all natural salmon spawning in the Elwha has been restricted to the lower 8 km of the river where the habitat continually has declined owing to interruption of the flow to spawning gravel from the headwaters. In 1992, the U.S. Congress passed the Elwha River Ecosystem and Fisheries Restoration Act with the goal of removing the two dams and fully restoring the Elwha River Ecosystem. The cost of removing the dams has been estimated from $147 to $203 million, with the majority associated with removing and stabilizing accumulated sediments behind the dams.

Puget Sound has also experienced a great deal of habitat modification. The coastal areas were extensively logged, and many coastal forests are being harvested for the second or third time. The area has rapidly become urbanized, and the population is growing faster in many rural areas than it is in the cities. In several rivers, summer flows are reduced due to agricultural diversions, and the flows of other streams are intermittent because of pumping from the aquifers for domestic water supplies. Industrialization and shipping have produced problems with contamination in Puget Sound, which, while usually not directly lethal to salmon, weakens their resistance to disease and their ability to avoid predators. Production of salmon in Puget Sound has been maintained at relatively stable levels through extensive hatchery programs for chinook and coho salmon and through less extensive programs for chum salmon.

Artificial Propagation

Historically, loss of natural salmon production to water development and hydropower projects has been mitigated by hatchery construction. Hatcheries also have been built for fisheries enhancement. The first fish culture facility on the U.S. West Coast was a salmon hatchery on the McCloud River in California, opened in 1872 by the U.S. Commission of Fish and Fisheries. Since then hatcheries have proliferated coastwide. Currently, hatcheries probably account for the majority of chinook and coho salmon production in California, Oregon, Washington, and Idaho, although the ratio of hatchery to natural production has not been estimated on a coastwide basis. Hatcheries initially were viewed as the salvation of salmon stocks and fisheries in the face of habitat destruction and degradation, but they have come under increasing scrutiny in recent years.

Production of natural populations may be depressed through competition with hatchery smolts for food and habitat, and predation of natural fry by larger hatchery smolts. Juvenile hatchery fish often are larger than naturally produced juveniles because of earlier spawn timing and more favorable growing conditions in the hatchery. When huge numbers of hatchery smolts are released into rivers with native fish, they can reduce the availability of prey for the natural fish. The influx of hatchery fish also can disrupt the territorial behavior of naturally produced juveniles, causing them to emigrate prematurely from rearing areas. In addition, coho salmon rear for a year in freshwater before release, and when they are released from the hatcheries, may prey upon naturally produced fry emerging from the gravel.

Hatchery populations also tend to be more productive than naturally spawning populations. Some fisheries in the Columbia River and in Puget Sound are managed for hatchery production. This means that stocks are harvested at rates that natural populations cannot sustain. If natural stocks are subjected to the same harvest rates in mixed-stock fisheries, they will be eliminated. In the mainstem of the lower Columbia River, this has already occurred with coho salmon. In Puget Sound, the Washington Department of Fish and Wildlife has attempted to protect natural stocks by selecting hatchery broodstock with earlier run timing than the natural populations and by timing commercial fisheries in terminal areas to target hatchery stocks. Whether this is sufficient to protect wild populations remains to be seen.

One of the greatest criticisms of hatcheries is the impact they may be having on the genetic structure of natural populations. Hatcheries have been operated by a large number of public agencies as well as a few private organizations, and there has been no comprehensive program to manage the genetic makeup of hatchery stocks.

Several practices in artificial propagation

give rise to these criticisms. Over the years, hatchery broodstock and gametes have been transferred over broad geographic areas. There is concern that this movement of fish between hatcheries may have disrupted the genetic structure of natural salmon populations in North America. There is also some evidence that propagation of fish in hatcheries over many generations has resulted in domestication of some stocks, and that fish adapted to an artificial environment are less fit for life in the wild. Thus, when hatchery fish stray from the hatchery and spawn with wild fish they may decrease the fitness of the natural populations. Attempts to minimize interaction between natural and hatchery fish by actively selecting fish with dissimilar life histories means that when hatchery fish do spawn with natural fish, their progeny are even less likely to survive.

A relatively new aspect of artificial propagation is the increasing role of commercial aquaculture. Along the Pacific coast there have been several attempts at ocean ranching, which involves operating a hatchery that releases fish to the wild with the idea of harvesting the mature fish when they return to the hatchery. Most ocean ranching operations have been unsuccessful, but the same model is being used successfully in Alaska for pink salmon enhancement.

A more successful approach has been farming, or net-pen rearing, of salmon. Salmon farming involves rearing the fish entirely in captivity, usually in floating net-pens. The production of farmed salmon on a global scale has been steadily increasing since the late-1970s, and in 1994, global production of farmed salmon exceeded the total commercial fishery production of Alaska. While most farmed salmon are Atlantic salmon (*Salmo salar*), chinook and coho also are raised.

From a market standpoint, farmed salmon have several advantages over salmon harvested in the fisheries: production is predictable and relatively stable, while natural production may fluctuate widely; fresh fish can be supplied year-round, while most wild salmon fisheries are highly seasonal; and fish quality is more consistent than in the commercial catch. As the industry continues to improve domesticated strains of salmon and to develop better feeds, the attractiveness of farmed salmon should continue to increase as its capital cost decreases.

Endangered Species

The Endangered Species Act (ESA) considers a species to be endangered if it is in danger of extinction throughout all or a significant portion of its range and threatened if it is likely to become endangered in the foreseeable future. The ESA also allows listing distinct population segments as unique "species." Because of declines in a number of individual salmon populations, NOAA Fisheries has received several petitions to list runs of salmon and anadromous trout for protection under the ESA.

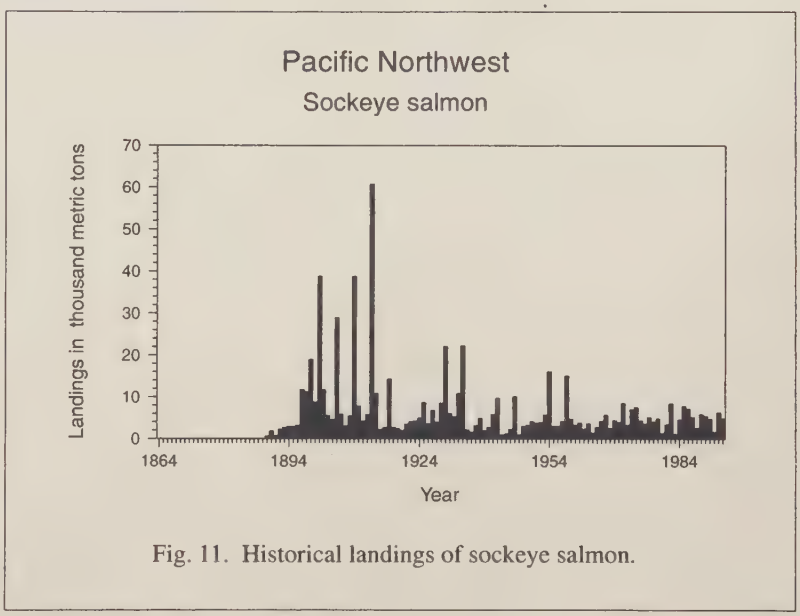


Fig. 11. Historical landings of sockeye salmon.

Because the ESA does not define the term "distinct population segment," NOAA Fisheries has developed a policy to define this term for Pacific salmon. According to this formula, a salmon population (or group of populations) can be considered distinct only if it constitutes an evolutionary significant unit (ESU). In order to qualify as an ESU, a population segment must be enough isolated reproductively from other population segments to allow genetic differences to occur, and it must comprise a significant component of the evolutionary legacy of the species as a whole. Currently, Snake River spring/summer chinook salmon are listed as threatened, and Sacramento River winter run chinook salmon, Snake River sockeye salmon, and Snake River fall run chinook salmon have been listed as endangered under the ESA. NOAA Fisheries has proposed listings for Umpqua River coastal cutthroat trout, and

Klamath Mountains Province steelhead trout.

Because of the large number of petitions received, the agency has undertaken coastwide ESA status reviews of all species of Pacific salmonids. The process involves determining the boundaries of the ESUs that comprise each species and the status of each ESU. Completion of these comprehensive status reviews should streamline the process of reviewing future petitions for listing salmon runs under the ESA.

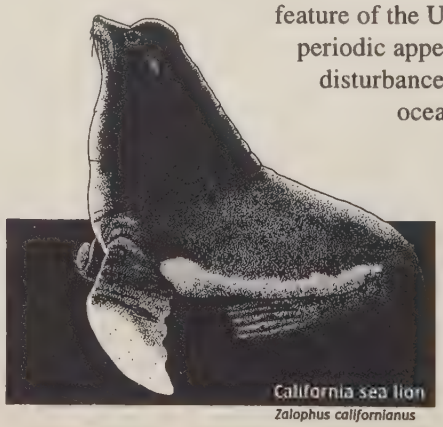
Marine Mammal Interactions

Pacific salmon stocks have had highly publicized interactions with other protected species. Prior to the passage of the MMPA, seals and sea lions were routinely shot by fishermen. Populations of marine mammals were kept at low levels, and their interactions with the fisheries were relatively minor.

The MMPA has been extremely successful in restoring some species, notably the northern elephant seal, the harbor seal, and the California sea lion. Populations of seals and sea lions have increased in some areas to the point where they are now causing problems for fisheries. For several years there have been complaints from the marine commercial and recreational fishing industries that California sea lions have become a substantial source of noncatch mortality associated with ocean fishing.

Sea lions follow fishing boats and wait for fish to be hooked, then prey upon the hooked fish. The rate of sea lion predation on hooked salmon has not been extensively studied, but anecdotal reports suggest that it is substantial. Aggregations of seals and sea lions also have been observed in estuaries and at river mouths where salmon congregate as they begin their upstream migration. The magnitude of the problem has not been studied extensively, but the numbers of marine mammals observed indicate that they potentially may be a large source of salmon mortality.

The most visible example has been at the Ballard Locks on the ship canal near downtown Seattle, Washington. The locks are a popular gathering place for tourists and locals alike, and all salmon and steelhead migrating upstream to Lake Washington must pass through the locks or through the fish ladder located there. In recent years, up to 20 young male California sea lions, collectively named "Hershel," have congregated at the locks to take advantage of the concentration of salmonids during their spawning migration. Steelhead runs in Lake Washington have declined precipitously in this time, and it has been estimated that the sea lions may be killing as much as two-thirds of the run each year. Attempts to deal with the sea lions have been unsuccessful: loud noises to frighten them away only resulted in sea lions overcoming their fear of loud noises. Several sea lions were trapped and relocated to California, only to return. After extensive review, NOAA Fisheries finally announced plans to use lethal removal as a method of last resort, but there has been tremendous public outcry in defense of the sea lions.



California sea lion
Zalophus californianus

Marine Environment

Pacific salmon spend much of their lives and achieve the vast majority of their growth in the marine environment, yet relatively little is known about how variability in the marine environment affects their growth and survival. However, with improvements in our capability for global data collection and remote sensing, patterns in oceanographic features on larger spatial and temporal scales are emerging.

One well-known environmental feature of the U.S. Pacific coast is the periodic appearance of El Niño, a disturbance in the upper layers of the ocean originating in the eastern tropical Pacific Ocean and producing abnormally warm surface waters off the coasts of California, Oregon, and Washington. This surface warming is associated with reduced upwelling and reduced productivity of coastal waters, and with a corresponding production decline in many fisheries, including those of chinook and coho salmon.

Productivity in the eastern North Pacific now appears to be driven substantially by changes in the entrainment of the North Pacific West Wind Drift Current. This current, which originates as an extension of the Kuroshio Current, approaches the North American

continent in the vicinity of the U.S.-Canada border. There the current splits and is diverted southward into the California Current along the U.S. west coast and northward into the Alaska Gyre in the Gulf of Alaska. When more of the West Wind Drift is diverted to the south, the California Current is strengthened. This is associated with colder water and with increased productivity off the west coast of the contiguous United States. When more of the West Wind Drift is entrained into the Alaska Gyre, the California Current is weakened and productivity decreases. At the same time, a strengthened Alaskan Gyre is associated with warmer temperatures and increased productivity in the Gulf of Alaska.

Changes in the entrainment of the West Wind Drift are driven by changes in global atmospheric circulation patterns and seem to occur on decadal scales. Since about 1977, conditions have favored entrainment of the West Wind Drift into the Alaska Gyre most of the time. The changes in productivity associated with this change in ocean currents have affected different salmon species in different ways. All salmon stocks in Alaska have benefited from increased productivity in the Alaska Gyre.

Pacific Northwest sockeye, chum, and pink salmon all migrate far offshore and to the north, and have benefited from increased productivity in the Alaska Gyre. Chinook and coho salmon from California, and Oregon tend to remain in coastal waters, and they have suffered from reduced productivity in the California Current system.

Chinook and coho salmon from the Columbia River northward tend to remain in coastal waters, but migrate still further north. The effects on these stocks have varied depending on the migration pathway and feeding grounds of individual stocks. Chinook salmon from the upper Columbia River tend to migrate far to the north and have maintained their productivity. Coastal stocks of chinook and coho salmon from Washington and northern Oregon and those from Puget Sound also tend to migrate to the north, but not as far as upper Columbia chinook. These stocks have experienced declines in productivity, but not as severe as those of stocks to the south. Attempts to evaluate the effects of any management impacts on Pacific salmon will always be confounded by variability in the marine environment.

Discussion

Salmon fisheries have always been a prominent feature of the cultural heritage of the Pacific Northwest. For thousands of years Northwesterners have identified with the fish, and with the activity of fishing for them. Now the futures of both fisheries and fish seem to be in question.

While salmon fisheries in Puget Sound have maintained their total landings in recent years, non-tribal fisheries have been severely reduced since the Boldt decision. Tribal fisheries have benefited from the Boldt decision and have increased their take from a minor fraction of the landings to a major component. Within Puget Sound, fisheries are presently supported primarily by species that have relatively little dependence on freshwater habitat, on production originating from the Fraser River in Canada, and on hatchery production of chinook and coho salmon.

Non-tribal fisheries in the Pacific Northwest face difficult times. Landings have been reduced recently to protect spawning escapements. Non-tribal commercial fisheries have also seen their share of the harvest decrease as a result of recent changes in allocation. Recent record landings of Alaska salmon and the increasing production of farmed salmon have driven prices down and undermined the toehold that Pacific Northwest commercial fisheries have traditionally maintained in the market. With additional constraints likely to result from recovery efforts for endangered species, the economic viability of these fisheries is doubtful.

The plight of Pacific salmon is particularly compelling because their dependence on freshwater to complete their life cycle has always made them very visible, available, and vulnerable. The challenges they overcome on their spawning migrations are inspiring, yet it is this same dependence on fresh water that currently threatens them. There are still some healthy natural pink and chum salmon populations in the Pacific Northwest, but it is increasingly difficult to find healthy natural populations of species that spend more of their lives in freshwater. The human population in the Pacific Northwest continues to increase, and people are also dependent on fresh water. The challenge we face with preserving these magnificent fish is to protect the needs of the species while accommodating the needs of the people. ❑

Marine Mammal Protection Act

• Keeping Pace with Wildlife Conservation •

Introduction

When the Secretary of the Interior produced his 1945 report on the "Fishery Resources of the United States," he noted that whale stocks worldwide were at an all time low. In that report, Remington Kellogg reported that the U.S. whaling industry had at one time engaged some 735 vessels and 40,000 people, representing an investment of $40 million and an annual harvest worth $8 million. However, in 1943, this fishery was reduced to only 3 vessels and employed 59 people; capital investment was less than $1 million and the annual harvest worth only $44,000. This dramatic turn was representative of the decline of whaling world wide and largely due to overharvesting.

The next three decades saw increases in some marine mammal populations (e.g., gray whales, humpback whales, California sea lions), while others declined (e.g., Hawaiian monk seals, Steller sea lions). These developments were coincident with the decline of many commercially valuable fisheries resources. In response, scientists and resource managers began to focus their attention on alternatives to traditional single-species conservation regimes. The growing recognition of the need for ecosystem-level resource management was reflected in legislative actions of the 1970s and 1980s, including: the Marine Protection, Research, and Sanctuaries Act; the Coastal Zone Management Act; the National Environmental Policy Act; the Marine Mammal Protection Act; the Endangered Species Act; and the Magnuson Fisheries Conservation and Management Act. In recent years discussion of holistic multispecies management and the sustainable use of renewable resources has included the issue of maintenance of biodiversity. A key concern was the potential effect of resource utilization on the diversity and stability of ecosystems. This is particularly true for marine ecosystems, where community structure has been significantly altered by the depletion of principal prey and predator species.

From its inception in 1972, the Marine Mammal Protection Act (MMPA) has reflected the need for ecosystem-based management in its primary goal—"to maintain the health and stability of marine ecosystems." Three explicit charges are to: 1) maintain animal stocks at optimum sustainable population (OSP) levels as functioning elements of their ecosystems, 2) restore depleted stocks to OSP levels, and 3) reduce incidental mortality and serious injury to "insignificant levels approaching a zero mortality and serious injury rate." The legislative record of the MMPA frequently refers to another implicit goal, which is to minimize interference with commercial fishing enterprises while meeting the other goals.

The MMPA has been reauthorized several times and amended in response to advances in our understanding of marine mammal population dynamics evolving legal, political, and economic landscape surrounding marine wildlife conservation and management. In this regard, the most recent amendments include mandates to undertake studies of the Bering Sea and Gulf of Maine ecosystems, and directs research toward multispecies interactions between pinniped populations and the fisheries. With each reauthorization, however, the fundamental conservation goals of the Act have prevailed.

1994 MMPA Amendments

The most significant recent event affecting the conservation and management of U.S. marine mammals was the enactment on April 30, 1994 of Public Law 103-238, the Marine Mammal Protection Act Amendments of 1994. These amendments supersede the five-year exemption from the MMPA for most commercial fisheries enacted by the 1988 MMPA amendments. During this five-year exemption period NOAA Fisheries developed a regime for the long-term management of marine mammal/fisheries interactions. The regime is based on a scientific rationale for determining how many marine mammals may be incidentally taken; it reflects sound principles of wildlife manage-

ment; and it is consistent with and implements the intent of the legislative act. Two aspects of the revised MMPA are discussed below: Stock Assessment Reports (SARs), which represent the starting point for evaluating the status of U.S. marine mammals at the beginning of the new regime; and the Potential Biological Removal (PBR), a concept that establishes a quantitative process for setting levels of take such that marine mammal stocks will equilibrate within their optimal population size.

Regional Stock Assessment Reports

The amended MMPA requires the Secretary of Commerce and the Secretary of the Interior to jointly develop SARs for all marine mammal stocks found within waters of U.S. jurisdiction. This does not apply to stocks having a remote possibility of occurring regularly in U.S. waters. The U.S. Fish and Wildlife Service (USFWS) has sole authority for stocks of Pacific walrus, Alaska polar bear, West Indian manatee, and Alaska and California sea otters, while NOAA Fisheries is responsible for the remaining cetaceans and pinnipeds (155 stocks, including 10 eastern tropical Pacific dolphin stocks). SARs are assigned to three separate regions—Alaska, Pacific including Hawaii, and Atlantic including the Gulf of Mexico. Three regional scientific review groups were established to review the SARs and identify areas of uncertainty and research needed to address them. They also advise the Secretaries on issues that affect the conservation of marine mammal stocks and their interactions with the commercial fisheries. The review groups are composed of 10–12 persons with expertise ranging from marine mammal population dynamics and modeling to commercial fishing technologies to represent a balance of regional, conservation and industry expertise, interests, and concerns.

The MMPA requires SARs to include how listed stocks are defined, minimum abundance estimates, current and maximum net productivity rates, current population trends, calculations of PBRs, and assessments of whether incidental fishery takes are "insignificant and approaching zero mortality and serious injury rate". Additonal requirements include an assessment as to whether the level of human-caused mortality and serious injury is likely to reduce the stock to below OSP, or whether the stock should be classified as a "strategic stock." SARs are to be reviewed annually for "strategic stocks" and for stocks for which new information is available. Stocks not otherwise considered are to be reviewed at least once every three years.

Strategic stocks are those that are listed as endangered or threatened under the ESA, or declining and likely to be listed in the foreseeable future. Strategic stocks also include those designated as depleted under the MMPA (i.e., below OSP), and those for which human-caused mortality exceeds the estimated PBR. When implemented by NOAA Fisheries and USFWS, the new MMPA mangement regime will contribute to the long-term database needed to detect and evaluate trends for all U.S. marine mammal stocks.

The 1994 Amendments require that take reduction teams be formed for each strategic stock and charges these teams with developing a take reduction plan to reduce takes to below the PBR. Plans for strategic stocks must be submitted to the Secretary within six months of the convening of a team. Team membership includes representatives of federal and state agencies, appropriate regional fishery management councils, interstate fisheries commissions, academic and scientific organizations, environmental groups, all commercial and recreational fisheries groups and gear types that impact the stock, Alaska Native organizations or Indian tribal organizations, and others as the Secretary deems appropriate.

The Potential Biological Removal Process

The 1994 MMPA amendments established, for the first time, the fundamental concept for calculating PBRs or sustainable removal levels for marine mammal stocks. Section 117 defines PBR to mean, "the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its OSP. The PBR is the product of the following factors:

Humpback whale
Megaptera novaeangliae

(a) the minimum population estimate of the stock, N_{MIN}.
(b) one-half the maximum theoretical or estimated net productivity rate (R_{MAX}) of the

stock at a small population size.
(c) a recovery factor (F_R) of between 0.1 and 1.0."

NOAA Fisheries interprets the PBR approach as an extension of precautionary resource management. The primary intent is to respond to the greater degree of uncertainty that is associated with assessing and reducing marine mammal mortality from incidental fisheries takes, as compared to mortality from directed harvests.

Advantages of the PBR approach are that it is not based on any particular population model, it allows conservative management to proceed when lacking detailed information, it provides an incentive to improve information on stock size by increasing precision (i.e., lowering coefficients of variation, CVs), it is based on readily measurable quantities, and it focuses on achievable goals.

Recognizing that the authorizing legislation provided only limited guidance for implementing the PBR process, and the need to establish quantitative criteria for calculating PBRs that could be consistently applied across regions, NOAA Fisheries, in consultation with the USFWS and the Marine Mammal Commission, convened a series of workshops and meetings in 1994. Guidelines for calculating PBRs for marine mammal stocks, including quantitative criteria for making those calculations, were developed. Once parameter values for the three PBR elements (N_{MIN}, R_{MAX}, and F_R) were identified, their performance were evaluated using statistical simulations to explore the behavior of hypothetical populations under a range of precision about these input variables. The simulations indicated optimal parameter values that met the MMPA goals of the recovery of depleted stocks, and maintenance of stocks within OSP with 95% probability within 20-100 years (Fig. 12). For example, it was found over a range of abundance estimate CVs, from 0.2 to 0.8, that using the 20th percentile of the abundance estimate for N_{MIN} was sufficient to allow populations to recover to or remain within OSP. This occurred in the absence of problems such as biased estimates of abundance or mortality, while meeting both the 20-year and 100-year criteria. Further simulations called "robustness trials" were undertaken to explore the effects of unknown bias or other problems with input parameter valuess, including underestimation of mortality by as much as 50%. Simulations indicated that a F_R value of 0.50 (for pinnipeds and for cetaceans), in combination with the 20th percentile of the abundance estimate, resulted in all populations equilibrating near OSP within the specified time period.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) is defined in the 1994 MMPA amendments as an estimate of the number of animals in a stock "that:

(a) is based on the best available scientific information on abundance, incorporating the precision and variability associated with such information; and,
(b) provides reasonable assurance that the stock size is equal to or greater than the estimate."

Consistent with these definitions, N_{MIN} is calculated such that a stock of unknown status would achieve and be maintained within OSP with 95% probability. Population simulations demonstrated that this goal can be achieved by defining N_{MIN} as the 20th percentile of a log-normal distribution based on an estimate of stock abundance:

$$N_{MIN} = N/\exp(0.842 * (\ln(1+CV(N)^2))^{1/2})$$

where N is the abundance estimate and CV(N) is the coefficient of variation of the abundance estimate. This is equivalent to the lower limit of a 60% 2-tailed confidence interval.

If abundance estimates are believed to be biased, appropriate correction factors are applied to obtain unbiased estimates of N. In such cases, the coefficient of variation for N includes uncertainty in the estimation of the correction factor. Where direct counts of animals are available, such as for many pinniped stocks, these direct counts are used as the estimate of N_{MIN}. Other approaches can also be used to estimate N_{MIN} provided the same level of assurance that the stock size is equal to or greater than that estimate is maintained.

Maximum Rate of Increase

One-half of the maximum rate of increase (R_{MAX}) is defined in the MMPA as "one-half of the maximum theoretical or estimated 'net productivity rate' of the stock at a small popula-

tion size." The term "net productivity rate" means "the annual per capita rate of increase in a stock resulting from additions due to reproduction, less losses due to natural mortality."

Consistent with a risk-adverse approach, these default values are near the lower range of measured or the theoretical maximum values that are thought to be plausible for a wide range of species (i.e., 0.12 for pinnipeds and sea otters and 0.04 for cetaceans and manatees). When reliable stock-specific information is available on R_{MAX}, such as an observed rate higher than the default, substitutions for these default values can be made in calculating PBR.

Recovery Factor

The MMPA defines the recovery factor (F_R), as being within the range from 0.1 to 1.0. Adding F_R to the definition of PBR ensures the recovery of populations to their OSP levels. This does not significantly increase the time necessary for endangered, threatened, or depleted populations to recover. Values of F_R less than 1.0 allocate a proportion of expected net production toward population growth and compensates for uncertainties that might prevent population recovery. These may include biases in the estimation of N_{MIN} and R_{MAX}, or errors in the determination of stock structure.

While values for N_{MIN} and R_{MAX} are adopted from strict criteria as starting points for calculating initial PBRs, the value of F_R can be "tuned." Tuning requires that reasonable assurance in the form of scientific justification or other reliable information is employed to ensure that the estimates of abundance, mortality, and R_{MAX} are not severely biased. Further, coefficients of variation of the abundance and mortality estimates must fall within accepted ranges.

Simulation studies demonstrate that to achieve the conservation goal of encouraging the recovery of stocks that are depleted (below OSP), the default F_R for depleted and threatened stocks and stocks of unknown status should be no greater than 0.5. The recovery factor of 0.5 for depleted or threatened stocks, or stocks of unknown status, was determined by the assumption that the coefficient of variation of the mortality estimate is equal to or less than 0.3. If the CV around the mortality estimate is greater than 0.3, the recovery factor must be further decreased to achieve stock recovery to OSP with 95% probability. F_R for stocks listed as endangered is assigned as 0.1.

Stocks known to be within OSP (e.g., as determined from quantitative methods such as dynamic response or back-calculation), stocks of unknown status that are thought to be increasing, or stocks taken primarily by aboriginal subsistence hunters that are not known to be decreasing, can have higher F_R values. These values may be up to and including 1.0, provided that there have been no recent increases in the levels of mortality.

The recovery factor is also used to accom-

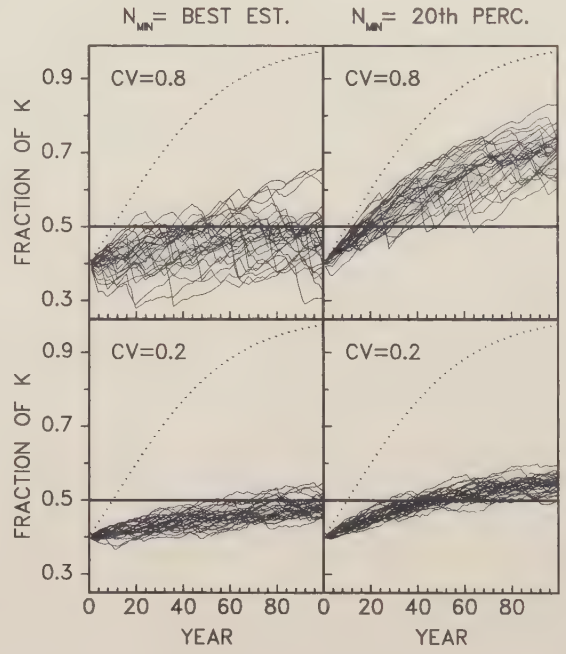


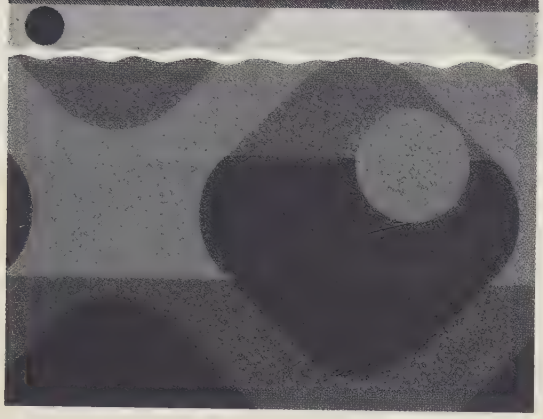
Fig.12. PBR Simulations. A sample of 30 cetacean populations simulated for 100 years for 4 different cases. PBR is calculated as the product of N_{MIN}, ½ R_{MAX} (0.02), and F_R (1.0), and is recalculated from a "new" abundance estimate every 4 years. The simulations assume that the entire PBR is taken each year as incidental fisheries mortality. The thick solid line represents a fraction of K (carrying capacity) of 0.5. Populations above that line are within their Optimum Sustainable Population level (OSP), whereas populations below that are considered depleted under the MMPA. Each population starts at a fraction of 0.4 K. The dotted line represents the trajectory of a population with no incidental fisheries mortality. The two panels on the left represent simulations using a best estimate of abundance (or point estimate) for N_{MIN}—the majority of the simulated populations are depleted after 100 years. The two panels on the right represent simulations using the 20th percentile of the abundance estimate for N_{MIN} (the lower 60% 2-tailed confidence limit), representing the strategy for calculating PBR adopted by NOAA Fisheries. In these panels, at least 95% of the simulated populations are within OSP after 100 years. The two upper panels represent simulations where the abundance estimate is relatively imprecise (CV=0.8), and the two lower panels represent simulations where the abundance estimate is relatively precise (CV=0.2).

modate additional information and allow for management discretion as appropriate and consistent with the MMPA goals. For example, if human-caused mortalities include more than 50% females, the recovery factor could be decreased to compensate for the greater impact of this mortality on the population (or increased if the mortalities are less than 50% female). Similarly, declining stocks, especially ones that are threatened or depleted, can be given lower recovery factors; the value of which may depend on the magnitude and duration of the decline.

Alternatively, recovery factors can be increased in some cases. If mortality estimates are known to be relatively unbiased because of high observer coverage, then it may be appropriate to increase the recovery factor to reflect the greater certainty in the estimates. For example, in the case where the observer coverage was 100% and the observed fishery was responsible for virtually all fishery mortality on a particular stock, the recovery factor for a stock of unknown status might be increased from 0.5 to 0.75. This action reflects reduced concern about bias in mortality, but continued concern about biases in other PBR parameters and possible errors in determining stock structure. Recovery factors of 1.0 for stocks of unknown status are reserved for cases where there is assurance that N_{MIN}, R_{MAX}, and the kill are unbiased, and where the stock structure is unequivocal or those cases where the population is not known to be adversely affected by human interactions. Where stocks are not known to be adversely affected by human activities, but whose status is unknown, recovery factors up to 1.0 are appropriate.

Throughout 1994 and the spring of 1995, NOAA scientists identified several opportunities for continuing or new research that would advance and assess the performance of the PBR-based regime for managing takes of marine mammals. NOAA Fisheries published the final versions of the SARs in the summer of 1995 and will conduct follow-up PBR workshops. ❑

Part 2 Living Marine Resources



Unit 1

Northeast Demersal Fisheries

Introduction

Northeast demersal (groundfish) fisheries include about 35 species and stocks, primarily in New England waters, but also off the Mid-Atlantic states. In New England, the groundfish complex is dominated by members of the cod family (cod, haddock, hakes, pollock), flounders, dogfish sharks, and skates. Mid-Atlantic groundfish fisheries are primarily summer flounder, scup, goosefish, and black sea bass.

Northeast groundfish fishermen employ fishing gears such as otter trawls, gill nets, traps, and set lines. Otter trawling is the predominant fishing method for groundfish throughout the region (there were 1,040 otter trawl vessels in the fleet in 1993); gill nets contribute a substantial proportion of the catch in the Gulf of Maine (244 vessels fished gill nets in 1993). Many of the vessels participating in the groundfish fisheries switch gears on a seasonal basis. Recent average (1992-94) landings (U.S., Canadian, and recreational) of mixed groundfish in the Northeast region were about 185,000 t, with the 1994 total being even lower at 152,000 t (Table 1-1), only 31% of the estimated long-term potential.

Groundfish resources in the Northeast occur in mixed-species aggregations, resulting in significant bycatch interactions among fisheries directed to particular target species or species groups. Management is complex because of these interactions. This complexity is reflected, for example, in the use of differing mesh, gear, minimum landing sizes, and seasonal closure regulations, set by such entities as the New England and Mid-Atlantic FMCs, the states, ASMFC, and by the Canadian government, because of the trans-boundary nature of some stocks. New England groundfish are managed primarily under the Northeast Multispecies FMP (13 species), as well as peripherally under provisions of the ASMFC Northern Shrimp Management Plan. Summer flounder and weakfish (primarily Mid-Atlantic species) are currently managed under FMPs, and additional FMPs are in preparation for scup and black sea bass. Demersal fisheries in New England have been managed primarily by indirect methods including mesh sizes, minimum fish lengths, and some area closures. There are currently no direct controls on New England groundfish fishing mortality rates through catch quota regulations, as in other regions, but an effort reduction program has been implemented, and in light of the recent collapse of the stocks of Atlantic cod,

Table 1-1. Northeast Demersal Fish Resources

Productivity in metric tons and status of fisheries resources

Species	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Groundfish & Flounders					
Atlantic cod [2,3,4]	33,100	16,000	45,000	Over	Below
Pollock[2,3,5]	29,200	29,000	37,000	Full	Near
Silver hake	16,000	16,000	100,000	Over	Below
Summer flounder[3]	8,500	6,600	26,000	Over	Below
American plaice	5,800	4,100	3,600	Over	Below
Winter flounder[3]	5,600	5,600	16,000	Over	Below
Yellowtail flounder[2]	4,600	500	39,000	Over	Below
Haddock[2,6]	4,600	5,000	52,000	Over	Below
Witch flounder	2,500	2,700	3,000	Over	Below
Red hake[3]	1,900	1,900	40,000	Under	Near
Windowpane	1,400	1,400	2,100	Over	Below
Redfish	700	700	14,000	Over	Below
Skates & Dogfish					
Spiny dogfish[2,3]	19,200	35,000	35,000	Full	Above
Skates	9,700	25,000	25,000	Under	Above
Other Finfish					
Goosefish[2]	18,200	Unknown	10,000	Over	Below
White hake[2,7]	8,100	5,500	7,700	Full	Below
Scup[3]	6,100	1,500	14,000	Over	Below
Black sea bass[3]	2,800	Unknown	Unknown	Over	Below
Spot[3]	2,000	Unknown	Unknown	Unknown	Unknown
Cusk[2,8]	1,900	1,500	1,500	Over	Below
Weakfish[3]	1,400	Unknown	Unknown	Over	Below
Tilefish	1,400	500	1,200	Over	Below
Wolffish	500	500	700	Over	Below
Ocean pout	300	300	Unknown	Full	Near
Atlantic halibut	35	Unknown	Unknown	Over	Below
Total	185,535	183,735	479,335		
U.S. Subtotal	145,900	136,634	402,365		

[1] 1992-94 average. Landings for 1994 are incomplete for some areas resulting in underestimated RAYs for some species.
[2] Includes more than 100 t/yr of foreign (Canadian) landings.
[3] Includes more than 100 t/yr of recreational landings.
[4] For cod, U.S. landings are 24,600 t (74% of RAY).
[5] For pollock, U.S. landings are 5,600 t (19% of RAY).
[6] For haddock, U.S. landings are 1,200 t (26% of RAY).
[7] For white hake, U.S. landings are 6,900 t (85% of RAY).
[8] For cusk, U.S. landings are 1,400 t (72% of RAY).

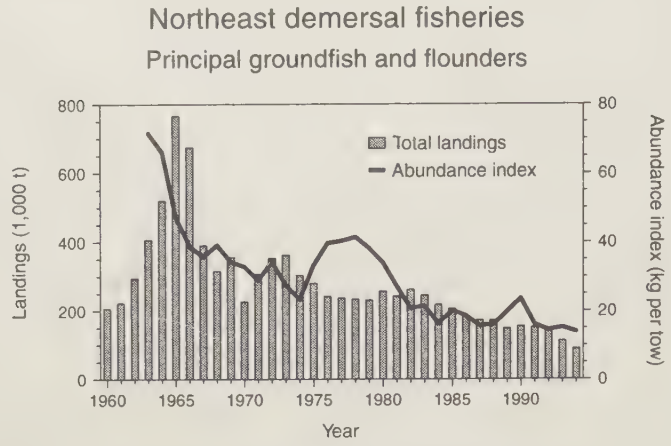


Fig. 1-1. Landings and abundance index of principal groundfish and flounders.

Northeast Groundfish & Flounder Landings (t)

1993	112,800
1994	89,200

haddock, and yellowtail flounder, there is the strong likelihood of some type of stringent catch controls being imposed soon. The Summer Flounder FMP includes provisions for catch quota targets aimed at restoring this depleted stock.

Extensive historical data for the Northeast demersal fisheries have been derived from both fishery-dependent (i.e., catch and effort monitoring) and fishery-independent (NOAA research vessel) sampling programs. Since 1989, a sea sampling program has been conducted aboard commercial vessels, in order to document discard rates and to collect high quality, high resolution data on their catch. Despite the past management record, some of the Northeast demersal stocks (cod, yellowtail flounder, haddock, American plaice, pollock) are among the best understood and assessed fishery resources in the country.

Species and Status

Principal Groundfish and Flounders

The principal groundfish and flounders group includes important cod-family species (Atlantic cod, haddock, silver hake, red hake, white hake, pollock), flounders (yellowtail, summer, winter, witch, windowpane, American plaice) and redfish (Fig. 1-1). Recent annual landings of these 12 species (19 stocks) have averaged 113,900 t (63% U.S. commercial, 32% Canadian, and 5% U.S. recreational), compared with LTPYs of 377,700 t (Table 1-1). Total ex-vessel revenue from principal U.S. groundfish and flounder commercial landings in 1994 was $118 million, compared to $161 million in 1992. The Northeast groundfish complex supports important recreational fisheries for species including summer flounder, winter flounder, and Atlantic cod.

The abundance index for this group declined by almost 70% between 1963 and 1974 (Fig. 1-1), reflecting substantial increases in exploitation associated with the advent of distant-water fleets. Many stocks in this group declined sharply, notably Georges Bank haddock, most silver and red hake stocks, and most flatfish stocks. By 1974, indices of abundance for many of these species had dropped to the lowest ever recorded.

Groundfish partially recovered during the mid-to-late 1970s because of reduced fishing effort associated with increasingly restrictive management under the International Commission for the Northwest Atlantic Fisheries (ICNAF) during the early-1970s, and implementation of the MFCMA in 1977. Cod and haddock abundance increased markedly; stock biomass of pollock increased more-or-less continually, and recruitment and abundance also increased for several flatfish stocks. The aggregate index peaked in 1978, but subsequently declined, reaching new lows in 1987 and 1988. The 1989 and 1990 abundance values were slightly higher than the previous two years, primarily due to recruitment of moderate 1987 year classes of Atlantic cod, haddock, and yellowtail flounder. However, subsequent abundance indices declined due in large part to the rapid depletion of the 1987 yellowtail flounder year class, and declining cod abundance. The 1994 index of groundfish abundance represented a time series (32-year) low. Landings of these species declined substantially in 1994 and are predicted to decline further in 1995 in the face of generally poor recruitment. Landings of cod, haddock, and yellowtail flounder are currently at the lowest level since the 1950s, when demand for fish and total fishing effort were low. Fishing effort directed to the groundfish complex reached a peak in 1992 and has since decreased.

Skates and Dogfish

Dogfish and skates are a significant and growing part of the aggregate groundfish stock biomass in the Northeast (Fig. 1-2). Of the two dogfishes (spiny and smooth), the spiny dogfish

is dominant by far. Seven species of skates, including little, winter, barndoor, brier, thorny, leopard, and smooth-tailed occur on the Northeast shelf: winter, little, and thorny skates produce most of the landings.

Skate and spiny dogfish landings underwent a marked increase from 2,700 t in 1978 to 31,400 t in 1992, and subsequently declined to 24,400 t in 1994. Recent annual landings averaged 28,900 t (Table 1-1). These landings levels are well below the long-term potential and current potential landings for these stocks. Abundance of skates and dogfish increased throughout the 1970s and 1980s, peaked in 1990, and declined each year since (Fig. 1-2). Despite these recent declines, overall abundance of skates and dogfish continues to remain high, although a 1994 assessment suggested that the spiny dogfish stock was near full exploitation. Increases in dogfish and skate abundance, in conjunction with declining abundance of groundfish and flounders, have resulted in the proportion of dogfish and skates in Georges Bank survey indices increasing from roughly 25% by weight in 1963 to nearly 75% in recent years.

Other Finfish

Other groundfish species taken primarily as bycatch in the Gulf of Maine include goosefish, white hake, cusk, wolffish, and Atlantic halibut. In Southern New England, goosefish and ocean pout are important groundfish stocks, and in the Middle Atlantic, scup, weakfish, black sea bass, spot, tilefish, and several others are landed either in directed fisheries or as bycatch. As a group, they are characterized generally as overexploited, with recent annual landings totaling about 42,700 t, below the long-term maximum (Table 1-1). Most of these stocks are managed implicitly with other species included in various FMPs. For example, white hake, goosefish, cusk, wolffish, and halibut are taken in various groundfish fisheries regulated under the Northeast Multispecies FMP. Although scup and black sea bass represent major components of the summer flounder directed fishery, separate FMPs are under development for these stocks. ASMFC has developed an FMP for weakfish, and several other stocks are slated for inclusion in future FMPs.

The advent of directed fishing for goosefish at the edge of the continental shelf in the Middle Atlantic and Southern New England areas has prompted interest in developing regulations for that fishery, primarily because very small individuals are landed from that fishery and as bycatch from sea scallop dredge fishing. Landings of goosefish have tripled since 1987 as a result of a sharp decline in the abundance of principal groundfish and flounders, and increased market demand, particularly for livers whose ex-vessel price can reach as high as $12-13/lb. In 1994, the U.S. commercial landings of goosefish were 18,600 t, valued at $26 million, making it the top-ranked demersal species in landings in the Northeast, exceeding even Atlantic cod for which the U.S. landings dropped to 17,500 t (valued at $36 million).

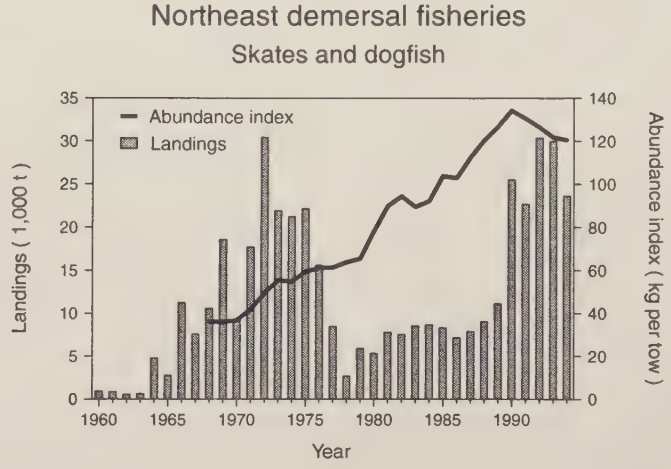


Fig. 1-2. Landings and abundance index of skates and dogfish.

Issues

Management Concerns

Northeast Skates and Dogfish Landings (t)

1993	30,000
1994	23,600

Until recently, New England groundfish resources were regulated by indirect controls on fishing mortality, including mesh and minimum fish size restrictions, and some area closures. In the face of persistent overfishing of the resource, the Conservation Law Foundation (CLF) and the Massachusetts Audubon Society filed litigation aimed at stopping overfishing. A consent decree was entered into between NOAA Fisheries and CLF stipulating that measures be developed that would eliminate the overfished condition of cod and yellowtail in 5 years and haddock in 10 years.

Amendment #5 to the New England Multispecies FMP began an effort reduction program in 1994 to address these requirements. The regulatory package included a moratorium on new vessel entrants, a schedule of reduction in days at sea for trawl and gillnet vessels, increases in regulated mesh size, and expanded closure areas to protect haddock. The objective of the plan was to gradually eliminate the overfished condition of cod, yellowtail flounder, and haddock over 5-7 years. In light of a determination made late in 1994, based on new assessments that further declines in the abundance of cod, haddock, and yellowtail flounder on Georges Bank had led to the collapse of these stocks, development of Amendment #7 to the New England Multispecies FMP was begun for the purpose of reducing fishing mortality on these stocks to $F_{0.1}$ levels.

In contrast, the Summer Flounder FMP has instituted a strategy to reduce fishing mortality by 50% from 1992 to 1993 and eventually to achieve F_{max}. The Summer Flounder FMP uses catch quotas, allocated by state and season, to achieve these management goals. Recently, increased recruitment levels, combined with lower fishing mortality rates in 1993 and 1994, have resulted in increased biomass.

Transboundary Stocks and Jurisdiction

Significant catches are taken from transboundary stocks of Atlantic cod, haddock, and pollock from Canadian waters of Georges Bank and the Gulf of Maine. In 1994, 22% of the cod, 88% of the haddock, and 80% of the pollock landings were taken by Canadian fishermen. Management regulations employed by the two countries are fundamentally different: Canada seeks to achieve target fishing mortality rates through catch quota regulation. Although there is coordination of stock assessment activities between the countries, there is no formal mechanism for joint management. This lack of coordinated management effort has contributed to the severe overfishing of the shared resources.

Atlantic cod
Gadus morhua

Economics

Satisfying the conditions imposed by the overfishing definitions of the Multispecies and Summer Flounder FMPs will require significant effort reductions. Rebuilt stocks eventually would provide increased net benefits to producers and consumers, but in the short-term, effort reductions will curtail revenues to fishermen, and raise prices to consumers. In order to rebuild the collapsed stocks of cod, haddock, and yellowtail flounder to threshold levels of spawning stock biomass capable of producing good recruitment, which could take 7-12 years. Very substantial reductions in fishing effort will be necessary in the New England area which will force many vessels out of the fishery. The ultimate net benefits of these effort reductions over Northeast groundfish resources will be both positive and substantial to the Nation as a whole.

Progress

Considerable progress in the development of management alternatives for the Northeast demersal resources was made during 1994. The implemented measures include days-at-sea reduction, increased minimum mesh sizes, a moratorium on new vessels, expanded closed areas to fishing, and trip limits for depleted haddock stocks. An annual review provision allows the level of effort reduction measures to be changed, depending on the actual state of fishing mortality relative to plan targets. Mandatory reporting systems for Northeast resources have been developed to better monitor the performance of the fishery. New measures are still under development to immediately and substantially reduce fishing mortality on stocks of cod, haddock, and yellowtail flounder below the levels required under Amendment #5 in order to rebuild spawning stock biomass back where recruitment prospects are likely to be enhanced over the long term. Revised assessments for principal species including cod, haddock, pollock, yellowtail flounder, witch flounder, American plaice, and white hake have documented patterns of fishing mortality, discarding, and recruitment, and form the basis for additional regulatory proposals.

Management of the summer flounder stock has proceeded with a short-term goal of reducing fishing mortality by 50% from 1992 to 1993, and eventually achieving F_{max}. A series of state-by-state allocations of the annual quota has been the primary regulatory measure. With improved recruitment, coupled with reduced fishing mortality, catch rates for the commercial and recreational sectors improved in 1993. Lower fishing mortality rates and slightly improved recruitment will result in increased landings and a rebuilding of the spawning stock biomass and its age structure (currently comprised primarily of age 0-2 fish). ❑

Northeast Pelagic Fisheries

Introduction

Northeast pelagic fisheries harvest stocks of Atlantic herring, Atlantic mackerel, butterfish, bluefish, and short- and long-finned squid. These fisheries are seasonal and reflect the migratory patterns of the six primary pelagic species. In general, the pelagics overwinter in relatively warm offshore waters of the Mid-Atlantic continental shelf and southward to avoid seasonal cooling of nearshore waters and undertake northward and inshore migrations during the spring and summer to feed. Various fishing gears including bottom trawls, mid-water trawls, gillnets, and seines are used to harvest pelagics in the Northeast region. During 1992-94, commercial landings averaged 157,400 t (68% U.S. and 32% Canada) and recreational landings (primarily composed of bluefish and mackerel) averaged 8,400 t, for a total of 165,800 t (Table 2-1). In 1994, U.S. and Canadian commercial landings totaled 135,500 t, while U.S. recreational landings were 7,600 t. The ex-vessel value of the 1994 U.S. commercial landings was roughly $56 million, over 75% of which ($42 million) was generated by landings of short- and long-finned squid. Recreational landings of bluefish and mackerel are also important in the Northeast region. For example, over $300 million is spent annually by recreational anglers fishing for bluefish.

The two principal Northeast pelagics, Atlantic mackerel and Atlantic herring, were exploited heavily by distant water fleets during the 1970s. As a result, stock sizes and yields of mackerel and herring declined to very low levels by the late-1970s. Since that time, their abundance has increased substantially due to low harvest rates and improved recruitment.

Northeast pelagic fisheries are managed under the following three FMPs, the first two developed by the Mid-Atlantic FMC and the third by the ASMFC: 1) the Squid, Mackerel, and Butterfish FMP, 2) the Bluefish FMP, and 3) the Atlantic Sea Herring FMP.

Species and Status

The Northeast pelagic fisheries are dominated by six species: Atlantic mackerel, Atlantic herring, bluefish, butterfish, and two squids: long-finned (*Loligo pealei*) and short-finned (*Illex illecebrosus*). Four stocks are considered to be underutilized (mackerel, herring, short-finned squid, and butterfish). The long-finned squid stock is considered to be fully utilized, while the bluefish stock is considered to be overutilized. At present, the abundance of mackerel, herring, and butterfish stocks is above average. The short- and long-finned squid stocks are considered to be near their average level of abundance, while the abundance of bluefish is below average.

The long-term population trends for mackerel and herring, as measured by research vessel survey data, have fluctuated considerably during the last 25 years (Fig. 2-1). The mackerel and herring abundance index reached minimal levels in the mid-to-late 1970s, reflecting pronounced declines for both species (as well as the collapse of the Georges Bank herring stock). The abundance of both species has been increasing in recent years.

Table 2-1. Northeast Pelagics

Productivity in metric tons and status of fisheries resources

Species	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Atlantic herring[2,3]	81,800	250,000	150,000	Under	Above
Atlantic mackerel[2,4,5]	30,700	385,000	150,000	Under	Above
Squids					
Long-finned	21,000	36,000	36,000	Full	Near
Short-finned	18,100	30,000	30,000	Under	Near
Bluefish[4]	10,600	7,300	30,000	Over	Below
Butterfish	3,600	16,000	16,000	Under	Above
Total	165,800	724,300	412,000		

[1] 1992-94 average (including foreign and recreational landings). Landings for 1994 are incomplete for some areas resulting in underestimated RAYs for some species.
[2] Includes significant foreign (Canadian) landings.
[3] For herring, U.S. landings are 53,200 t (65% of RAY).
[4] Included significant recreational landings.
[5] For mackerel, U.S. landings are 9,100 t (30% of RAY).

The Atlantic mackerel stock recovered during the 1980s, and the latest stock assessment indicates that the spawning stock biomass is around 2 million t. In comparison, recent annual

landings were 30,700 t (Table 2-1). Although the size of the mackerel stock is imprecisely known because removals due to natural mortality far exceed those due to fishing mortality, it is clear that mackerel landings could increase several-fold without jeopardizing stock productivity. There are also indications that growth and maturity rates of mackerel declined as stock size increased during the 1980s.

Atlantic Mackerel Landings (t)

1993	31,600
1994	22,400

The Atlantic herring stock complex of the Northeast region is considered to be underutilized. Total landings of herring were 67,500 t in 1994 (U.S. landings were 45,300 t), a 22% decrease from 1993. The coastal stock complex consists of two major stock groups in U.S. waters: Gulf of Maine and Georges Bank. Canadian catches off New Brunswick also are included in the combined stock analysis since these fish mix with Georges Bank and Gulf of Maine herring during portions of the year. The Georges Bank herring stock had collapsed by 1976 after intensive exploitation by distant-water fleets during the 1960s and early-1970s. There are promising indications that the Georges Bank herring stock has recovered, based on recent U.S. and Canadian bottom trawl and ichthyoplankton surveys. Overall, the herring stock is increasing in abundance and can support increased landings.

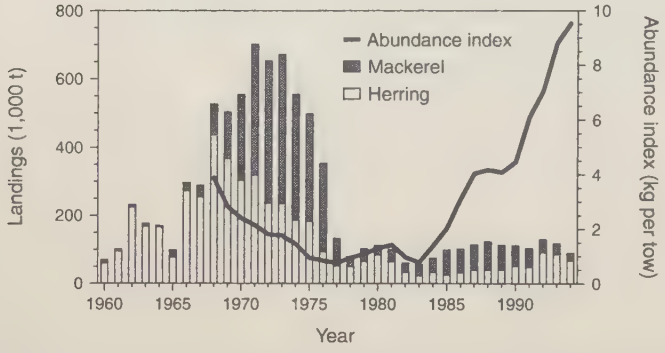


Fig. 2-1. Landings of Alantic herring and Atlantic mackerel and their combined abundance index.

Atlantic Herring Landings (t)

1993	86,100
1994	67,500

Bluefish landings peaked in 1980 at 72,600 t, but have declined to a recent annual average of only 10,600 t (Table 2-1). The majority of bluefish landings (over 80%) are taken by recreational fishermen. The recent downward trends in recreational and commercial landings reflect declining stock biomass. Currently, the bluefish stock is overutilized and at a low level of abundance.

In 1994, commercial landings of long-finned squid were 22,500 t and generated over $31 million in ex-vessel revenue. Recreational landings of long-finned squid are insignificant. The RAY for the stock is 21,000 t. Catch rates in the long-finned squid fishery vary seasonally due to the short lifespan (about 1 year) and rapid growth of this species. In recent years, the majority of the landings have been taken during the winter fishery in offshore waters of the Mid-Atlantic Bight and Southern New England. Management targets for long-finned squid are being reevaluated to reflect recent research on its life history. The stock is currently near its average level of abundance and is considered to be fully utilized.

Short-finned squid landings in 1994 were a domestic record of 18,350 t with an ex-vessel value of $10 million. In recent years, landings have been stable and have averaged 18,100 t (Table 2-1). Recreational landings of short-finned squid are insignificant. The short-finned squid stock is highly migratory, and a portion of this transboundary stock is seasonally available for harvest in Canadian waters. The lifespan of short-finned squid is about 1 year, based on recent research. The stock is currently near its average level of abundance and is considered to be underutilized relative to historic yields.

The butterfish stock is considered to be underutilized, based on current research survey results and historic landings patterns. Butterfish landings have declined significantly in recent years to less than 4,000 t per year, primarily due to reduced export demand. The stock is currently being fished well below its LTPY (Table 2-1) and is considered to be above average in abundance based on research survey indices.

Issues

Scientific Advice and Adequacy of Assessment

Although historical data on catches and fishing effort are adequate for assessment purposes, stock assessments for the Northeast

pelagic resources are relatively imprecise, owing to the highly variable trawl survey indices of relative abundance used for calibrating cohort analysis models, the short life span of some stocks (squids and butterfish), and current low exploitation rates of some species (mackerel and herring). The development of more precise assessments of these stocks likely will require the use of hydroacoustic sampling, combined with trawl surveys to separate species components of the pelagic resource. More precise assessments for short-lived stocks will depend on the availability of more appropriate survey and commercial performance data.

Underutilized Species

All of the pelagic stocks, except bluefish and long-finned squid, are considered to be underutilized. Total recent average yields (165,800 t) could be more than doubled and still not reach the aggregate long-term potential yield for the Northeast pelagics (412,000 t, Table 2-1). The aggregate current potential yield (724,300 t) is more than four times the total recent average yields. Although current estimates of stock sizes for the principal pelagic stocks are relatively imprecise (see above), the foregone yields for mackerel and herring are substantial, and harvests could be substantially increased without jeopardizing the productivity of these stocks.

Bycatch and Multispecies Interactions

Concentrations of schooling fish such as the Northeast pelagics are utilized by a wide variety of predatory fishes, marine mammals, and birds. In winter months, fisheries directed for Atlantic mackerel and herring historically have taken some marine mammals, including pilot whales and common dolphins. An intensification of these fisheries to take advantage of these underutilized resources might result in greater marine mammal kills. The burgeoning stocks of mackerel and herring could lead to an increased level of predation mortality on larval fishes, particularly on Georges Bank and in Southern New England during late winter and spring. ❑

Atlantic mackerel
Scomber scombrus

Unit 3

Atlantic Anadromous Fisheries

Introduction

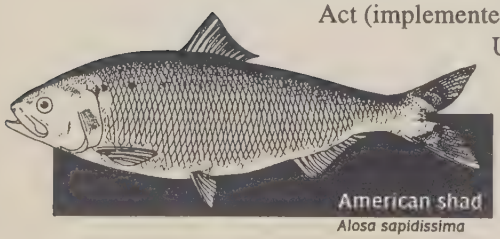
The anadromous species of the Atlantic seaboard are a diverse group, including river herrings (alewife, blueback herring, hickory shad), American shad, striped bass, Atlantic salmon, sturgeons (Atlantic and shortnosed), and rainbow smelt. Regulation of these stocks is likewise diverse: ASMFC has implemented FMPs for shad and river herring, and Atlantic sturgeon, while shortnosed sturgeon is managed under a recovery plan prepared under the Endangered Species Act. Atlantic salmon are regulated by a New England Council FMP, and under the auspices of the North Atlantic Salmon Conservation Organization (NASCO). Striped bass are regulated under an ASMFC FMP and special Congressional authority under the Striped Bass Conservation Act (implemented by NOAA Fisheries and USFWS).

Table 3-1. Atlantic Anadromous Fish Resources

Productivity in metric tons and status of fisheries resources

Species	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Striped bass[2]	3,600	Unknown	Unknown	Full	Above
American shad	700	Unknown	Unknown	Over	Below
Alewife/blueback	300	Unknown	Unknown	Over	Below
Sturgons	33	Unknown	Unknown	Over	Below
Atlantic salmon	3	Unknown	Unknown	Full	Below
Total	4,836	4,836	4,836		

[1] 1992-94 average (including foreign and recreational landings). Landings for 1994 are incomplete for some areas resulting in underestimated RAYs for some species; for alewife/blueback and American shad, higher assumed 1994 landings were used in calculating RAY.
[2] Includes significant recreational landings.



American shad
Alosa sapidissima

Recent average landings of Atlantic anadromous species (Table 3-1; Figs. 3-1 and 3-2) are only 4,800 t, far below historical levels. Several of the species are of major recreational importance to the region (including American shad, striped bass, and Atlantic salmon). The recreational portion of the recent average landings is about 2,800 t, virtually all of which is of striped bass.

Landings of Atlantic anadromous species have declined greatly in recent years. River herring catches peaked in the 1960s at about 27,000 t coastwide, but have since declined to less than 2,000 t annually. Likewise, commercial landings of American shad had a recent peak of 3,000 t in 1970, but are now averaging only about 700 t/year. Striped bass commercial landings were over 6,000 t in 1973, but decreased to less than 1,000 t by 1985. Following several years of severe management restrictions, regulations have maintained commercial striped bass landings at about 800 t/year. Catches of U.S. origin Atlantic salmon, taken primarily in foreign commercial fisheries, were in excess of 10,000 fish/year during the 1980s. Currently, domestic and foreign fisheries on Atlantic salmon are, for the most part, closed by regulation or private quota purchase agreement.

Species and Status

Unlike most of the offshore resources of the Northeast, Atlantic anadromous stocks have heavily been influenced by non-fishing human activities in the coastal zone. Damming of rivers preventing access to former spawning grounds was a major factor in the decline of Atlantic salmon, sturgeons, river herrings, and shad. Environmental contamination is implicated in the decline of several species. Today, not only are these species threatened by coastal pollution and development, but interception fisheries (sometimes far from the spawning grounds) are considered problematic to the recovery of some species.

Atlantic Salmon

Atlantic salmon historically spawned in river systems throughout New England. As a consequence of industrial and agricultural development, most runs native to New England have been extirpated. Today, the only self-supporting runs in the United States are in Maine. Restoration efforts, in the form of stocking and fish passage construction, are

underway in the Connecticut, Pawcatuck, Merrimack, and Penobscot rivers. In U.S. rivers, juvenile salmon are resident in freshwater streams for 2 or 3 years before migrating to the sea. While at sea, they generally undergo extensive migrations to the waters off Canada and Greenland.

The abundance of Atlantic salmon stocks in Maine rivers is represented by estimates of catch and run size (Fig. 3-1). The abundance of U.S. stocks, like most stocks in North America, has declined during the past decade. Home water fisheries (those in U.S. waters) are limited to angling in Maine. The number of salmon kept by anglers has exceeded 1,000 fish/year. However, current low salmon stock abundance has prompted a complete ban on the retention of fish in the recreational fishery. Tagging experiments have demonstrated that distant-water fisheries commercial gillnet fisheries off Canada and Greenland) have exploited U.S. stocks at approximately 50%. These commercial oceanic fisheries are regulated under the auspices of NASCO. Canadian interception fisheries have been regulated by time-area restrictions and quotas. Beginning in 1992, the fishery in Newfoundland was closed for a 5-year period. The Greenland fishery is quota controlled, but in recent years, the quota has been purchased by private agreement.

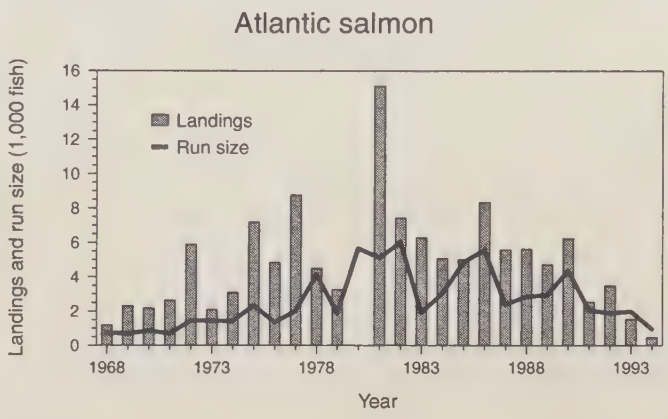


Fig. 3-1. Spawning run size of Atlantic salmon returning to Maine rivers and total catch (by U.S. anglers from Maine rivers and at-sea foreign catches).

Striped Bass

Four primary stocks of striped bass occur along the Atlantic coast: Hudson River, Delaware Bay, Chesapeake Bay, and Roanoke River (NC). Striped bass stocks historically have supported important commercial and recreational fisheries, with recreational harvests often equaling or exceeding commercial landings (Fig. 3-2). Commercial fisheries are prosecuted with a variety of gears including haul seines, trawls, pound and gillnets, and hook-and-line. Commercial landings peaked in 1973 and then began a precipitous decline. The declining landings coupled with consistently poor recruitment indices in the Chesapeake Bay provided the impetus for highly restrictive management actions taken by ASMFC in the mid-1980s. Additionally, Congress passed the Striped Bass Conservation Act, which empowered the Departments of Commerce and Interior to impose a moratorium on striped bass fishing in any state which ASMFC found not to be in compliance with its FMP.

The fisheries were monitored closely and under severe management restrictions. However, a high recruitment index in 1989 in the Chesapeake Bay (Fig. 3-2) triggered a slight relaxation of management restrictions and allowed increased fishing pressure on migratory Atlantic striped bass stocks the following year. Recruitment has continued to improve and the growth of the population has reached a level of abundance equivalent to the mid-1970s, prior to the decline. As a result of the improved conditions, ASMFC has declared Atlantic striped bass fully restored, allowing a further relaxation of management regulations in the commercial and recreational fisheries. Modeling studies indicate that the resource should continue to increase if fishing annually removes 27% or less of the legal-sized fish.

Atlantic Salmon Landings (Number of Fish)	
1993	1,500,000
1994	500,000

Issues

Transboundary Stocks and Jurisdiction

The interception of U.S.-origin salmon in commercial fisheries off Canada and West Greenland represent a major impediment to the restoration of runs and homewater fisheries. The catch of U.S.-origin fish in interception fisheries has been about 10 times the homewater recreational catch. Beginning in 1992, the largest portion of the Canadian fishery, that around Newfoundland, was closed for a moratorium

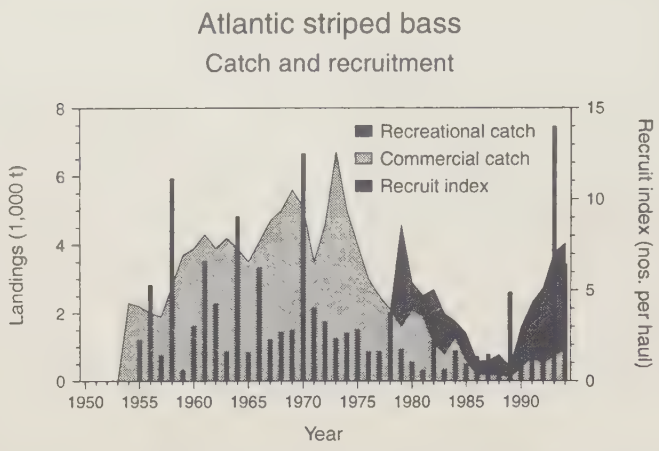


Fig. 3-2. Striped bass catch and recruitment index (Maryland seine index) of young fish in Chesapeake Bay.

Atlantic Striped Bass Landings (t)

	Com.	Rec.
1993	800	3,000
1994	900	3,100

period of five years. Likewise, the Greenland fishery quota, which was set to meet spawning escapements to North American rivers, was purchased by a private conservation agreement and removed from the fishery.

Endangered Species Concerns

Anadromous Atlantic salmon populations throughout their range in the U.S. were petitioned for listing under the Endangered Species Act. NOAA Fisheries and USFWS, working in partnership, formed a biological review team to evaluate the status of these populations. The two agencies determined that available biological evidence indicated that the population structure described in the petition did not meet the definition of species under the Act. The team concluded that native population segments south of the Kennebec River were extirpated. However, the agencies have published a proposed rule to list a population complex in 7 Maine rivers containing remnant native populations as threatened. The final decision on this proposed rule will be made in 1996. The salmon populations in 4 additional rivers warrant further study and the agencies are actively investigating their status.

Management Controls

An issue of particular concern for striped bass is the potential impact of discard mortality. Recreational fishing effort for striped bass currently far exceeds commercial effort, and over 90% of the recreational catch was released alive during the early-1990s. Even with high survival rates of hooked and released striped bass, the large number of fish subjected to hooking mortality may compromise the conservation benefit of high minimum sizes. Another concern as the striped bass population expands is the increased likelihood of striped bass bycatch in non-directed commercial fisheries. There is a desire by all interests not to negate the progress made in rebuilding the severely depleted spawning stocks in Chesapeake Bay. ❑

Northeast Invertebrate Fisheries

Introduction

Offshore fisheries for crustaceans and bivalve mollusks are among the most valuable of the region's fisheries. For the ninth straight year, U.S. commercial landings of American lobster (27,600 t) and sea scallop (7,500 t) in 1994 ranked first and second in overall ex-vessel value with $167 million and $83 million, respectively. Additionally, landings of surfclam, ocean quahog, and northern shrimp contributed another $61 million in revenue. The combined value of these fisheries exceeds that for all offshore finfish fisheries combined. Four separate fishery management regimes regulate the harvest of these species: the Surf Clam/ Ocean Quahog FMP of the Mid-Atlantic FMC, and the Sea Scallop FMP of the New England FMC. The northern shrimp fishery is regulated by the ASMFC. At present, American lobsters are regulated partially under an FMP promulgated by the New England FMC, but individual states are the primary regulators of these fisheries. A comprehensive inshore/offshore management plan for American lobsters is currently under development by the New England FMC.

Species and Status

American Lobster

Comprehensive stock assessments of the American lobster resource, last completed in 1993, indicated fishing mortality rates on the Gulf of Maine resource to be about 20% above the New England FMC's overfishing level. Overfishing of the resource inshore from Cape Cod through Long Island Sound was substantially greater, while the offshore continental shelf portion of the resource was being exploited at approximately the overfishing level. A large fraction of all lobsters landed are sexually immature and fishing mortality rates for both inshore and offshore populations greatly exceed the rates that would provide maximum cohort yields. The intent of management is to increase egg production per recruit through a variety of regulatory measures. At present, American lobster populations are regulated primarily by a minimum carapace length set at 3¼ inches (83 mm). The New England FMC, in cooperation with the ASMFC, NOAA Fisheries, and the fishing industry, is now considering additional measures that include limitations on numbers of traps, seasonal closures, increases in the size of escape vents, and overall quotas.

Recent average landings of lobsters have been 25,900 t (Table 4-1), with landings in 1994 at about the CPY level. The 1994 harvest (27,600 t) was second only to the record catch of 29,100 t taken in 1991 (Fig. 4-1).

Atlantic Sea Scallop

Sea scallops are harvested on the continental shelf from the Virginia Capes to the Hague Line, separating the U.S. and Canadian portions of Georges Bank, and in the Gulf of Maine. Canadian landings on Georges Bank represent a significant fraction of the total (Fig. 4-2), i.e., 37% (5,800 t) of RAY (Table 4-1). Sea scallops are harvested primarily using epibenthic dredges in the Gulf of Maine, Georges Bank, and the Mid-Atlantic Bight. A small but rapidly growing proportion of the landings is taken with otter trawls in the Mid-Atlantic.

Table 4-1. Northeast Invertebrates

Productivity in metric tons and status of fisheries resources

Species	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
American lobster	25,900	27,500	Unknown	Over	Above
Sea scallop[2,3]	15,400	12,500	13,300	Over	Near
Surfclam[2]	31,800[4]	30,200[4]	22,000[5]	Full	Above
Ocean quahog[2]	22,500	22,000	25,000	Full	Near
Northern shrimp	3,100	5,000	4,000[6]	Full	Near
Red crab	800	2,700	2,700	Unknown	Unknown
Total	99,500	99,900	94,500		
U.S. Subtotal Only	93,568	95,056	89,357		

[1] 1992-94 average. Landings for 1994 are incomplete for some areas resulting in underestimated RAYs for some species; for lobsters, preliminary 1994 landings were increased by 25% for calculating this RAY.
[2] Data for bivalve species are in shucked meat weights.
[3] Transboundary stock with Canada, which harvested 37% (5,800 t) of RAY.
[4] Reflects landings from both inshore and offshore areas.
[5] Only for the U.S. EEZ.
[6] Provisional LTPY, based on historical landings pattern (1963-94).

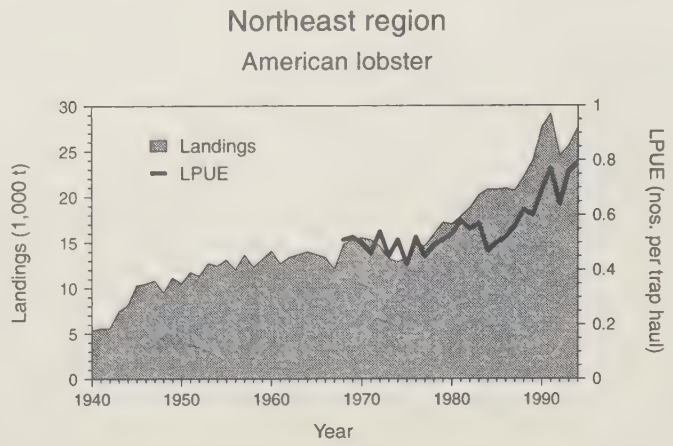


Fig. 4-1. U.S. American lobster landings and Maine landings per unit effort.

American Lobster Landings (t)

1993	25,600
1994	27,600

Management of the sea scallop fishery by the New England FMC changed markedly in 1994 as maximum meat count regulations (numbers of scallop meats per pound) were eliminated. In their place, controls on the number of days at sea and increased mesh ring sizes were instituted. The effects of these measures cannot yet be evaluated, but a comprehensive assessment through 1993 indicated that the resource was being overfished on Georges Bank and in the Mid-Atlantic Bight and was at a low overall level of abundance. Sea scallop populations are characterized by wide variability in year-class strength and little relationship among dominant cohorts between the Mid-Atlantic Bight and Georges Bank. Several strong year classes resulted in record high U.S. landings in 1990-91 of about 17,000 t (Fig. 4-2), but landings declined abruptly in 1993 to only 7,400 t and remained at that level in 1994, reflecting much poorer recruitment in recent years. Fisheries in all areas depend almost entirely on the growth of new recruits into the exploitable size range. In the Mid-Atlantic Bight, moderate year classes in 1990 and 1991 are supporting current landings. Given the rapid growth, low natural mortality rates, and early age at entry by this species into the fishery, considerable yield is currently being foregone to growth overfishing. Current fishing mortality rates also exceed recruitment overfishing definitions.

Surfclam and Ocean Quahog

These species are harvested with hydraulic dredging vessels; the majority of EEZ landings occur off New Jersey and the Delmarva Peninsula. Small quantities of them are also taken off Southern New England and in the Gulf of Maine. Fisheries for these species are currently closed on Georges Bank due to paralytic shellfish poisoning (PSP) contamination. They are managed under the Surf Clam and Ocean Quahog FMP of the Mid-Atlantic FMC. The primary management measure is a system of individual transferable quotas (ITQs) allocated on the basis of historical participation in the fisheries.

Atlantic surfclam landings increased steadily during the 1960s and early-1970s, peaking in 1974. Subsequently, a succession of poor year classes, combined with a large die-off of the surfclam resource off the New Jersey coast in 1976 led to very low stock biomasses and reduced landings. Beginning in 1977, the FMP has regulated total annual surfclam landings from the EEZ (where most landings are derived) and has addressed the significant overcapitalization in the fishery. Large year classes spawned in 1976 and 1977 off New Jersey and the Delmarva Peninsula even now comprise a significant fraction of the harvestable stock. Evidence from the most recent assessment suggests consistent but modest levels of recruitment. Under current harvest quotas, there is sufficient biomass to support surfclam catches off northern New Jersey and Delmarva for 8 to 11 years. Recent annual landings have averaged 31,800 t (Table 4-1).

Ocean quahog landings increased rapidly as the surfclam resource collapsed in the mid-1970s, and a market substitute for processed clam products was developed. They inhabit relatively deep waters of the Mid-Atlantic continental shelf and Georges Bank. In the Gulf of Maine they are found relatively nearshore in these cooler waters. Ocean quahogs are one of the longest lived (>100 yr) and slowest growing marine bivalves in the world. Current annual landings are expected to deplete the resource in existing fishable areas in about 30 years. Over the past two decades, ocean quahog fisheries have moved progressively northward with most landings now coming from the Long Island area. Large resources still exist in Southern New England and Georges Bank, but these areas cannot be easily fished with existing technology.

Northern Shrimp

Northern shrimp are harvested exclusively from the Gulf of Maine using small mesh trawls. Northern shrimp are at the southern extent of their geographical range in U.S. waters as high abundance is generally associated with low water temperatures. The ASMFC regulates the northern shrimp fishery in the Gulf of Maine; regulations control the length of the harvesting season (December to May) and the gear to be used.

Issues and Progress

Individual Transferrable Quota

An important issue in the surfclam fishery has been the implementation of an ITQ system which has obviated the need for complex restrictions on the amount of effort and time each surfclam vessel could fish. The total surfclam fleet has been reduced substantially since implementation of the ITQ system: from about 160 to less than 100 vessels in the first year alone. In the future there is likely to be further consolidation of fishing to a smaller number of vessels, as well as construction of new, more efficient vessels to reduce overhead.

Scientific Advice and Adequacy of Assessments

Much progress in assessing the status of exploited invertebrate stocks of the Northeast region has been made in the past several years. Traditional age-based assessment techniques are difficult or impossible to apply to most invertebrates. Therefore, the focus has shifted to stage-based models in which transitions between stages are determined by growth dynamics and mortality rates. Such methods have not only proven valuable for estimation of mortality rates for scallops, lobsters, and surfclams, but also for the detection of rates of recruitment. The development of these techniques emphasizes the importance of obtaining reliable biological sampling of the catches for length composition. Biological sampling of these stocks remains problematic since, in the case of sea scallops, the product is partially processed at sea. An integrated assessment plan for surfclams, ocean quahogs, and scallops was recently completed by NOAA Fisheries and state scientists. These new assessments will provide the basis for evaluating management alternatives, as direct controls on fishing mortality are being considered for the fishery.

Management Controls

Fishing mortality rates on sea scallops are far in excess of those generating maximum cohort yields and exceed reference points for recruitment overfishing. In 1994, the New England FMC began implementation of a plan amendment aimed at reducing fishing mortality on sea scallops. Measures include provisions to reduce fishing effort through days-at-sea reductions and a moratorium on vessel entrants, while removing the meat count requirement. Meat count regulations did not control the overall rate of fishing mortality, but redirected mortality onto older scallops. To reduce fishing mortality rates on smaller scallops, Amendment #4 included an increase in the minimum 'ring size' to 3" in the chain bag at the aft end of scallop dredges. This hopefully will compensate for the removal of the meat count requirement by reducing mortality on small scallops.

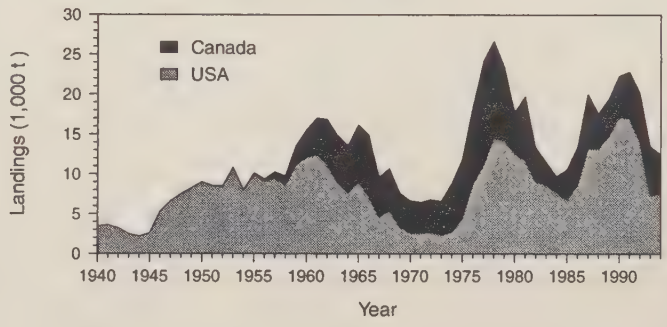


Fig. 4-2. U.S. and Canadian landings of Atlantic sea scallops from the mid-Atlantic, Gulf of Maine and Georges Bank regions.

Atlantic Sea Scallop Landings (t)	
1993	7,400
1994	7,500

Management of American lobsters is complicated by the international trade in live lobsters from Canada. The lack of conformity of imported lobsters with U.S. minimum size limits is a major political issue. The fact that the fishery is almost exclusively supported by

recently-molted animals is another serious concern for the long-term health and stability of these fisheries. The coherence in lobster landings increases in most western Atlantic areas implies that these increases may be due more to favorable environmental conditions for the survival of pre-recruits, than to the effects of management regulation or ecosystem change in any one area. Ongoing collaborative development of management measures by government and the fishing industry is an important approach to management.

Atlantic surfclam
Spisula solidissima

Invertebrate fisheries are likely to change rapidly in the next several years as increasing restrictions on finfish fisheries in the New England region displace groundfish harvesters from traditional areas. In the absence of regulations, a large influx of trawlers could offset many of the measures designed to reduce fishing mortality by scallop dredgers and lobster pots.

Bycatch and Multispecies Interactions

The trawl fishery for northern shrimp has generated considerable bycatch and associated discard of groundfish in the Gulf of Maine region. Growing concern over the fate of groundfish resources has led to the adoption of a fish-excluding device (the 'Nordmore Grate') as a condition of participation in this fishery. Sea sampling effort has been directed to this fishery to determine the impact of the use of this technology on bycatch rates of groundfish. Bycatch of goosefish in the sea scallop fishery has come under increased scrutiny as a source of fishing mortality on the goosefish stock as a whole, and particularly on very small fish. ❑

Atlantic Highly Migratory Pelagic Fisheries

Introduction

Oceanic pelagics are highly migratory species that include swordfish, bluefin tuna, yellowfin tuna, bigeye tuna, albacore, skipjack tuna, blue and white marlin, sailfish, longbill spearfish, and others. In the Atlantic Ocean, swordfish and bluefin tuna have long provided important fisheries, while in recent years yellowfin tuna and bigeye tuna have increased in importance to U.S. fishermen. Many recreational anglers target yellowfin and bluefin tuna, blue marlin, white marlin, and sailfish in U.S. waters and occasionally longbill spearfish. Commercial fishing for the latter four billfish species is now banned in U.S. waters; however, they are incidentally caught in tuna and swordfish longline fisheries.

Since Atlantic oceanic pelagics migrate widely and are harvested over broad oceanic areas by U.S. and foreign fishermen, both national and international management are necessary. In all cases, stock assessments are conducted using aggregate data, and provide the bases for regulations. U.S. fleets fish in the northwestern Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. These fleets are regulated under the Magnuson Fishery Conservation and Management Act (MFCMA) and the Atlantic Tunas Convention Act (ATCA), which provides authority to implement international agreements reached by the International Commission for the Conservation of Atlantic Tunas (ICCAT). U.S. fishery management plans have been developed for swordfish, blue marlin, white marlin, sailfish, and spearfish under the MFCMA. Management of Atlantic tunas and swordfish has been based largely on ICCAT recommendations, implemented via regulatory articles under ATCA. The Commission has set and allocated bluefin tuna quotas by country since 1982. The U.S. set domestic swordfish quotas beginning in 1991, but since 1995, country-specific swordfish quotas have been specified by the Commission.

Species and Status

From the early-1960s through 1977, U.S. fishermen caught an average of about 5,000 t per year (2,000-12,000 t/year) of oceanic pelagics (Fig. 5-1). Since 1978, U.S. fishermen have caught 8,000 t or more per year, and during 1991-93 they averaged 14,600 t/year. The U.S. share of CPY for oceanic pelagics is 14,700 t/year, and LTPY to the U.S. fleet is estimated at 19,100 t/year (Table 5-1).

Since 1960, the top species by volume in the U.S. harvest has shifted from bluefin tuna to swordfish to yellowfin tuna (Fig. 5-1) as each species declined due to fishing pressure. In 1961-73, bluefin tuna represented 45-80% of the U.S. western Atlantic catch of large pelagics. But since 1977, the percentage has dropped to less than 10%, reflecting the decline in the bluefin tuna population, catch restrictions, and the increasing harvests of alternative species. During 1961-73, swordfish represented 5-20% of the U.S. catch, rose to 60% in 1982, but has since dropped to about 25%. During 1961-83, the percentage of yellowfin tuna in the U.S. North Atlantic catch was usually less than 10%, but that has since risen to 35-45%.

The U.S. dockside commercial ex-vessel revenue from these fishes soared from about $20

Table 5-1. Atlantic Highly Migratory Pelagics

Productivity in metric tons and status of fisheries resources

Species / Area	Recent Average Yield (RAY)[2,3]	Current Potential Yield CPY[2]	Long-Term Potential Yield (LTPY)[2,3]	Fishery Utilization Level	Stock Level Relative to LTPY
Bigeye tuna (Atlantic)	79,700	Unknown	67,500	Full	Near
Albacore (N. Atlantic)	31,700	Unknown	38,000	Full	Near
Yellowfin tuna (W. Atlantic)	35,000	Unknown	33,000	Full	Near
Skipjack tuna (W. Atlantic)	28,400	Unknown	33,000	Full	Near
Swordfish (N. Atlantic)	16,000	12,000	12,800	Over	Below
Bluefin tuna (W. Atlantic)	2,500	2,000	6,700	Over	Far Below
Billfishes					
Blue marlin (N. Atlantic)	1,183	Unknown	1,700	Over	Below
White marlin (N. Atlantic)	253	Unknown	600	Over	Far Below
Sailfish (W. Atlantic)	619	Unknown	Unknown	Unknown	Unknown
Other tunas (Atlantic)	51,600	Unknown	Unknown	Unknown	Unknown
Total[1]	246,955	242,455	245,519		
U.S. Subtotal Only	14,600	14,700	19,100		

[1] Total LTPY, CPY, and RAY under present fishing patterns by U.S. and foreign nationals.
[2] 1991-93 average.
[3] Individual LTPYs, CPYs, and RAYs are based on entire stock, regardless of harvesting nation.

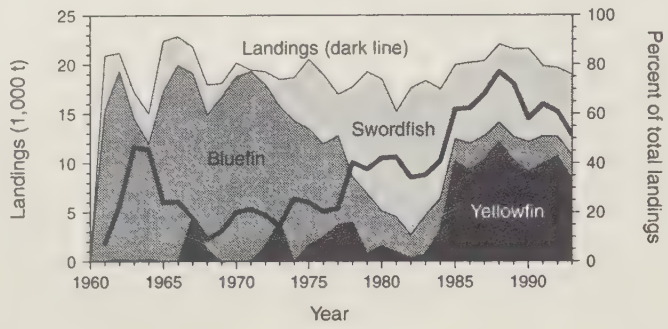


Fig. 5-1. U.S. landings of tunas, swordfish, marlins, and spearfish from the western North Atlantic Ocean, and the percentage of primary species.

U.S. Yellowfin Tuna Landings (t)

1992	6,500
1993	4,300

U.S. Bluefin Tuna Landings (t)

1992	1,200
1993	1,300

U.S. Swordfish Landings (t)

1992	4,200
1993	4,200

million (early-1980s) to nearly $100 million in 1988. The average annual commercial dockside value has remained at about this level since.

The value of the recreational fisheries for highly migratory species has not been estimated for all species; however, preliminary estimates indicate that they are highly valued.

Angler harvests of large pelagic fishes are estimated from dockside and telephone surveys. The average annual catch by recreational anglers for 1992-93 is estimated conservatively at 2,600 t. Fishing tournament surveys indicate a substantial increase in billfish fishing since 1972, although there are no precise data on these recreational anglers. Billfish tournament growth in some southern states indicates a fivefold to tenfold increase in this fishery since 1972. Although the practice of tagging and releasing of large pelagics has grown in recent years, more data are needed to quantify the recreational fishery trends for these fishes in the U.S. Atlantic and Gulf of Mexico waters.

There are a few Atlantic large pelagic species that appear to be underutilized and several that are overutilized. Bycatch of blue and white marlin by domestic and foreign fleets directing effort at other species has resulted in overharvesting of these stocks. Fishing mortality rates of swordfish have been excessive in recent years, prompting the development of international agreements to substantially reduce catches beginning in 1991. Harvests since July 1991 are consistent with ICCAT recommendations designed to reduce the risk of further declines. Western Atlantic bluefin tuna have been overharvested to the point of being severely depleted, and as a result the harvest of this species has been restricted since 1982. In spite of restrictions, there has been no apparent increase in adult numbers; however, the most recent ICCAT assessment indicates that current quotas may result in stock rebuilding in the future.

Issues

Transboundary stocks

Regulation of species that migrate across international boundaries is difficult. Domestic regulation without international agreements inherently is limited, but international agreements can be difficult to achieve. The latter is particularly true if the primary fishing nations cannot agree on fishing and conservation objectives, or do not abide by agreements once they are adopted. An additional problem is that not all fishing nations are members of ICCAT. The recent UN agreement on straddling fish stocks and highly migratory fish stocks may help to resolve these problems.

Bycatch and Multispecies Interactions

Marlin and sailfish bycatch in tuna and swordfish fisheries are a major concern, especially as commercial fisheries encounter concentrations of billfishes important to recreational anglers. Expansion of the U.S. longline fishery for Gulf of Mexico yellowfin tuna and Spanish longline fishing in the tropical eastern Atlantic have heightened concern for distressed Atlantic tunas, swordfish, and the billfishes sought by recreational anglers.

Domestic Management

The number of permits for large pelagics has been increasing substantially, concurrent with declines in stock size, partly as a result of spillover from other fisheries where limited access is being implemented.

Progress

In recent years scientists from the U.S. and several other nations have made substantial progress towards improving our understanding of the biological basis for managing Atlantic highly migratory fisheries. Analyses of the genetic structure of Atlantic and Mediterranean swordfish have been completed and have corroborated some of the stock structure assumptions made by ICCAT. Genetic studies of other large pelagic species and bluefin tuna in particular are underway. Additional studies of bluefin tuna stock structure using various tagging methods and biological markers are in various stages of planning and implementation. Several years of research on the growth and reproductive biology of male and female swordfish is being used to increase the understanding of the effect of fishing on the north Atlantic and Mediterranean management units. At recent ICCAT meetings (1994 and 1995), several recommendations and resolutions have been adopted that, if fully implemented, will result in substantial progress in conserving stocks and achieving the following management objectives: 1) resolutions to adopt recovery plans and rebuilding strategies for bluefin tuna and swordfish, 2) establishment of country-specific quotas for swordfish, 3) adoption of measures facilitating the monitoring of catch by both member and non-member countries, and the use of trade measures for non-member nations that fish in a manner that diminishes the effectiveness of ICCAT management measures, and 4) a recommendation to establish the first eastern Atlantic country-specific bluefin tuna quota (for France only).

Katsuwonus pelamis

At the domestic level, discussions on procedures to establish limited access for some large pelagics are currently well underway. ❑

Unit 6

Atlantic Shark Fisheries

Introduction

About 350 species of sharks are known worldwide. About 72 species frequent waters of the U.S. Atlantic, Gulf of Mexico, Puerto Rico, and U.S. Virgin Islands. For many years sharks were fished moderately and only in limited coastal areas. In recent years, large coastal sharks have been fished intensively over broad geographic areas. Sharks were first fished primarily for their livers (for vitamin A) and hides (for leather). Other minor products were fresh and salted meat, dried fins for Oriental sharkfin soup, and fish meal. The appearance of low-cost, synthetic vitamin A ended some of the small shark fisheries in 1950, and there was little demand for shark flesh or other products in the United States before 1970. From the 1980s, however, shark has become popular as food fish due to better handling, marketing, promotion, and an economy favoring low-cost shark over more expensive fish.

Table 6-1. Atlantic Sharks

Productivity in metric tons and status of fisheries resources

Species and Area	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Large coastal sharks[2]	5,245	4,253	5,280	Over	Below
Small coastal sharks[3,4]	2,719	3,600	3,600	Full	Above
Pelagic sharks[5]	1,360	Unknown	Unknown	Unknown	Unknown
Total	9,324	9,213	10,240		

[1] 1991-93 average.
[2] Includes sandbar, reef, blacktip, dusky, spinner, silky, bull, bignose, Galapagos, night, tiger, lemon, ragged-tooth, nurse, scalloped, smooth and great hammerhead, whale, basking, and white sharks.
[3] Includes Atlantic and Carribean sharpnose, finetooth, blacknose, bonnethead, and Atlantic angel sharks.
[4] Almost all of the small coastal shark yield is caught as bycatch in the Gulf of Mexico shrimp fishery and discarded at sea.
[5] Includes longfin and shortfin mako, blue, porbeagle, thresher, bigeye thresher, oceanic whitetip, sevengill, sixgill, and bigeye sixgill sharks.

Management of the Atlantic shark fisheries is covered in a shark FMP developed by NOAA Fisheries for the Secretary of Commerce. Since 1993, due to concerns about the sustainability of increased catches of sharks, limits on allowable catches of these species have been in effect.

Species and Status

The Atlantic shark fisheries are divided into three management groups: 1) Large coastal sharks [white, tiger, lemon, smooth and great hammerhead, basking, whale, blacktip, sandbar, reef, dusky, spinner, silky, bull, bignose, Galapagos, night, ragged-tooth, nurse, and scalloped]; 2) small coastal sharks [Atlantic and Caribbean sharpnose, finetooth, blacknose, bonnethead, and Atlantic angel]; and 3) pelagic sharks [longfin and shortfin mako, blue, porbeagle, thresher, bigeye thresher, oceanic whitetip, sevengill, sixgill, and bigeye sixgill]. Fig. 6-1 shows the recent catch trends for large coastal sharks. Catch rates for many of the species have declined considerably since the mid-1980s.

Large coastal sharks in both Atlantic and Gulf of Mexico waters are taken by anglers and longline fisheries. Pelagic sharks are targeted by tournament anglers, particularly off the Mid-Atlantic states, and are caught incidentally by swordfish and tuna longliners. The dockside ex-vessel revenue of the commercial shark fisheries has averaged more than $0.7 million annually in recent years.

Of the tournament and nontournament recreational trips, the latter are more prevalent. Nontournament anglers usually catch small coastal sharks that are generally not targeted by commercial fisheries. However, commercial and recreational fisheries do affect shark fishing of each other. The Gulf of Mexico shrimp fishery catches and discards many small coastal sharks (mostly sharpnose). Also, headboat anglers depend on blacktip sharks, a species seasonally taken by longline and drift gillnet fishermen. Many southern shark tournament anglers also fish for the same large coastal species taken by commercial fishermen. Tournament anglers farther north (Mid-Atlantic states and southern New England) fish for shortfin mako and blue sharks that are caught by large pelagic longline fisheries. In another twist, sharks taken by anglers along the Atlantic and Gulf coasts are often sold to commercial fish buyers (in 1986 about 9% of the "commercial" landings were

taken by rod-and-reel fishermen).

A mobile longline fishery also targets large coastal sharks in both Atlantic and Gulf waters, taking several species important to anglers. Fish buyers prefer sharks of 7-23 kg (dressed weight), but larger sharks have been taken just for their fins. Other boats use gill nets, including drift gill nets, to catch blacktip shark near shore in late summer and early autumn. Gulf snapper-grouper boats, particularly bottom longliners, also land sharks. Many sharks caught by Gulf shrimp trawlers are discarded at sea, but large valuable sharks are kept and sold.

Many sharks also are caught in the pelagic swordfish and tuna longline fishery. Some are discarded at sea, though certain species such as shortfin mako are regularly landed owing to their market value.

The data available on shark fisheries are very limited. Many species are landed and classified only as "shark" by fishermen and dealers in the market. To overcome some of these data deficiencies, newly developed assessment models were applied to the data available to generate assessment information by group. The summary on status of the stocks is given in Table 6-1. Large coastal sharks are considered overutilized; small coastal sharks are considered fully utilized. There is insufficient information to assess the status of pelagic sharks.

Issues

Scientific Information and Adequacy of Assessments

Species of shark are numerous and are difficult to distinguish. The market generally does not categorize sharks by species. This complicates scientific analysis. Thus assessments have been made for groups of species. There is a critical lack of data on shark numbers, biology, distribution, life history, and harvest. Without such data, it is difficult to assess the status of individual species.

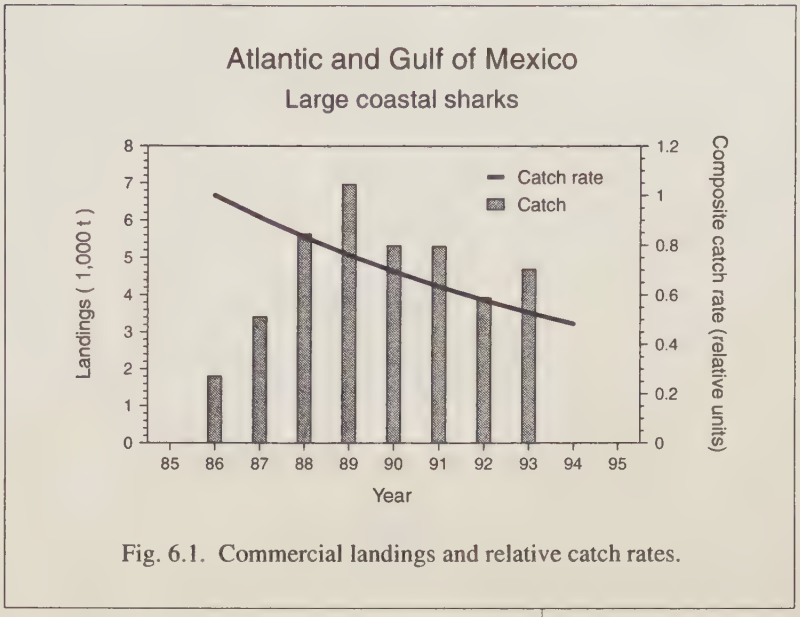


Fig. 6.1. Commercial landings and relative catch rates.

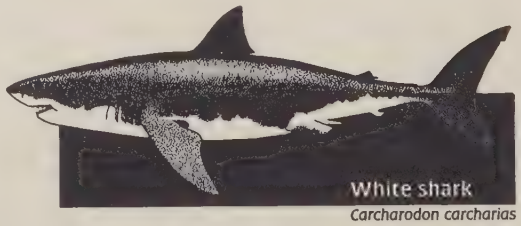
Management Concerns

Recreational and commercial fishermen have both voiced concern about declining shark populations. Because sharks grow and reproduce slowly, they are very vulnerable to overfishing.

Large Coastal Shark Commercial Landings (t)	
1992	5,300
1993	3,900

Progress

A new FMP was developed and implemented by NOAA Fisheries for sharks in 1993. It regulates commercial and recreational shark fishing to prevent overfishing, prohibit the practice of finning, discourage discarding of shark carcasses, rebuild currently overfished stocks, and improve data collection. In 1995, research via broad-scale fishery independent surveys was initiated. ❑


White shark
Carcharodon carcharias

Unit 7

Atlantic/Gulf of Mexico Coastal Migratory Pelagic Fisheries

Introduction

Coastal pelagic fishes inhabiting waters off the southeastern U.S. include king mackerel, Spanish mackerel, cero, dolphin, and cobia. These species range in coastal and continental shelf waters from the northeastern U.S. through the Gulf of Mexico and the Caribbean Sea and as far south as Brazil. Coastal pelagics are fast swimmers that school and feed voraciously, grow rapidly, mature early, and spawn over many months.

Scomberomorus cavalla

U.S. and Mexican commercial fishermen have fished Spanish mackerel since the 1850s and king mackerel since the 1880s. The Spanish mackerel fishery began off New York and New Jersey but shifted southward through the decades to the southern U.S. Atlantic and Gulf of Mexico. In 1990, over 90% of the commercial catch was landed in Florida. Although early commercial fisheries harvested Spanish mackerel by hook and line, nearly all the commercial catch now is taken by run-around gill net. A recreational fishery also exists for Spanish mackerel and accounts for about 25-42% of all the Spanish mackerel landed.

King mackerel are fished commercially from Chesapeake Bay southward. Four major production areas exist: North Carolina; lower Florida east coast (Cape Canaveral to Palm Beach); the Florida Keys; and Grande Isle, La. The Louisiana fishery began in the early-1980s; the area was believed to harbor older females that served as a major spawning population for Gulf of Mexico king mackerel. Unconstrained fishing mortality was believed to be high on these fish during the early-1980s, and these stocks currently comprise about 31% of the commercial quota for the Gulf regulatory group. Landings, which approached 680 t in 1983, were reduced one-half to two-thirds by federal quota management from the mid-1980s to the present.

Through the years, the commercial king mackerel vessels have employed gillnets, troll lines, handlines, purse seines, otter trawls, and pound nets. King mackerel sport fisheries exist off many southeastern states throughout the year. Commercial yields mostly were unregulated until the mid-1980s. Recreational landings are thought to have been reduced by an expanding commercial run-around gillnet fishery in the 1970s and a driftnet fishery in the late 1980s.

Coastal pelagics are co-managed under the Coastal Migratory Pelagic Resources FMP and regulations adopted by the South Atlantic and Gulf of Mexico FMCs and implemented by NOAA Fisheries. Total allowable catch and commercial and recreational allocations are established for two distinct migratory groups of king and Spanish mackerel: the Gulf group and the Atlantic group. Acceptable biological catches are estimated for separate geographical areas within the Gulf migratory group. Quota management began in the 1985-86 fishing year. Presently both commercial and charterboat operators must hold federal permits to fish for king mackerel, Spanish mackerel, or other coastal pelagics. Recreational catches are regulated by creel and size limits. In addition to quota limits, commercial catches must comply with minimum size restrictions and, off some states, daily landing limits and/or trip limits apply. Currently, only U.S. fishermen are regulated, while Mexican fishermen ar not. Mexican catches are thought to be large relative to the U.S. fishery.

Table 7-1. Atlantic Coastal Migratory Pelagics

Productivity in metric tons and status of fisheries resources

Species / Area	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Dolphin	4,430	Unknown	Unknown	Unknown	Unknown
King mackerel					
Gulf of Mexico	3,547	2,024	9,750	Over	Below
Atlantic	3,265	5,581	3,632	Under	Near
Spanish mackerel					
Gulf of Mexico	2,581	3,956	3,702	Full	Near
Atlantic	2,871	2,946	3,702	Full	Near
Cobia	1,168	Unknown	998	Unknown	Unknown
Cero	22	Unknown	Unknown	Unknown	Unknown
Total	17,884	20,127	26,236		

[1] 1991-93 average.

Species and Status

Recreational fishermen caught 8,000-17,000 t/year of coastal pelagic species, and commercial fishermen caught 5,000-14,000 t/year during 1979-91. King and Spanish mackerel account for about 95% of all coastal pelagic species harvested (Fig. 7-1, 7-2). In addition to king and Spanish mackerel, Atlantic dolphin and cobia contributed significantly to the total recreational yield of coastal pelagics. Some cobia are incidentally caught by commercial mackerel fishermen. Cero are relatively unimportant and are usually taken in other fisheries. Cero are not known to form large schools and are more difficult to target as a single species; in general they do not contribute significantly to coastal pelagic catches.

As a group, coastal pelagics yield only about 68% of their long-term potential (Table 7-1), and certain species are fished near or over maximum production levels. Three of the four mackerel stocks are considered overfished because of previous overexploitation and have been managed under rigid rebuilding schedules since 1985. The 1995/1996 Atlantic Spanish mackerel spawning potential ratio (SPR) is estimated to be 55% of its maximum potential. It is believed that fishing mortality from the shrimp bycatch fishery is greater than currently anticipated. Additional information is needed to quantify this source of mortality. Gulf Spanish mackerel were removed from overfished status in 1995 following a period of regulation to rebuild the stock that began in 1987. The 1995/1996 SPR has been estimated to be 29% of the maximum potential for Gulf Spanish mackerel. Currently, fishing mortality is less than $F_{30\%\ SPR}$, but additional information is needed on the exact level of bycatch to evaluate the stock status with more certainty.

The Gulf king mackerel stock is believed to have a large LTPY, but it is severely depleted. Recent average annual production is at 22% of its maximum level, and major stock reductions were due to excessive harvests from the late-1970s through the early-1980s. Absence of fishing controls and sparse data hampered conservation until 1986.

The Atlantic king mackerel group is near LTPY. Catches have remained stable since 1981 with annual total allowable catches (TACs) not reached in most years. Bycatch of Atlantic king mackerel is assumed low. The 1995-96 estimated SPR level is 55% of the maximum level.

Accurate assessment of the status of cobia and dolphin is not yet possible. Atlantic cobia yields have ranged from 351-627 t since 1987. Gulf cobia yields are about 1.3-23 times that of Atlantic cobia. Fishing mortality is assumed to be low for the Atlantic group, and Gulf cobia are believed to be more heavily exploited. The 1994 SPR calculation for Gulf cobia was about 25%. Management of cobia stocks assumes two separate stocks for assessment. Cobia and dolphin mostly are caught by recreational anglers, but data needed to assess LTPY are limited. In addition, updated information is needed to investigate the possibility of separating cobia stocks into Gulf and Atlantic groups. Also, refined estimates of cobia bycatch and natural mortality rate are needed to improve assessment of stock status.

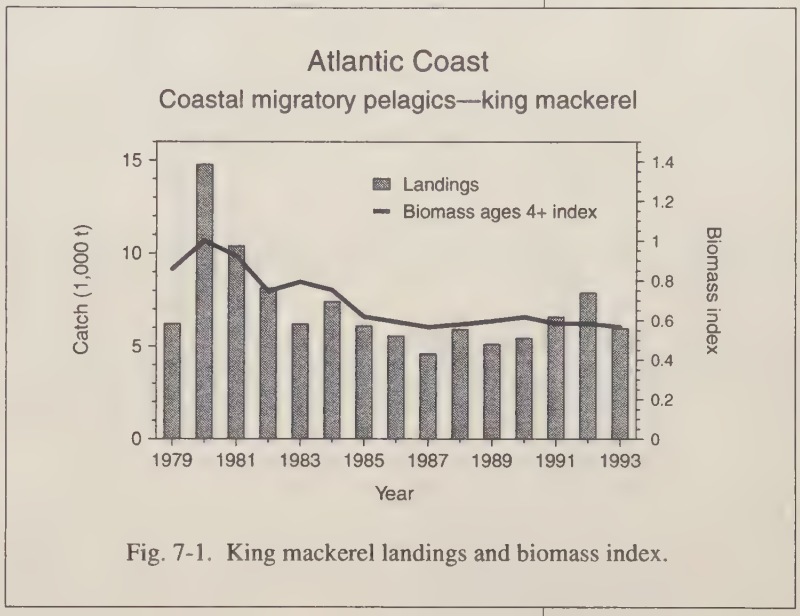


Fig. 7-1. King mackerel landings and biomass index.

Atlantic King Mackerel Landings (t)	
1992	7,900
1993	6,000

Issues

Transboundary Stocks and Jurisdiction

Effective management of migratory species will continue to require the coordination of Federal, state, and international regulatory actions. Accurate determination of the status of western Gulf of Mexico resources will require an increase in the information base on Mexican catches and their associated biological data.

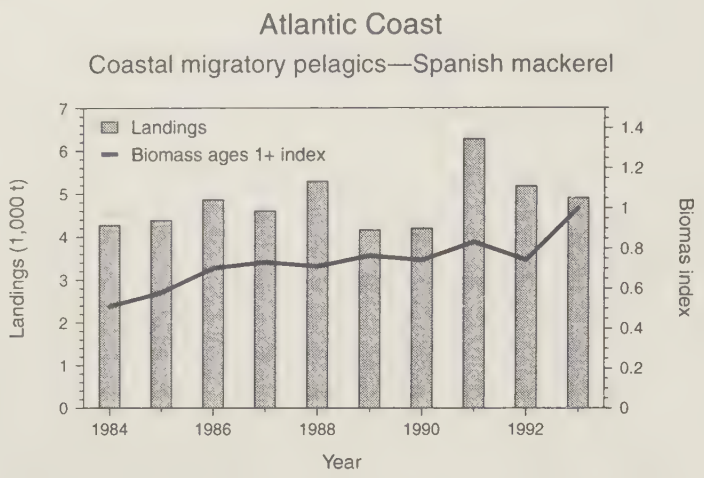


Fig. 7-2. Spanish mackerel landings and biomass index.

Atlantic Spanish Mackerel Landings (t)

1992	5,200
1993	4,900

Allocation

Allocation of TAC between recreational and commercial users remains an important issue. Future allocation decisions will require an increase in the precision and accuracy of user-specific harvest levels and in the understanding of the spatial segregation of the resource. ❑

Atlantic/Gulf of Mexico/Caribbean Reef Fish Fisheries

Introduction

Reef fish include more than 100 species that prefer coral reefs, artificial structures, or other hard bottom areas, and tilefishes that prefer muddy bottom areas. They range along the coast to a depth of about 200 m, from Cape Hatteras through the Gulf of Mexico and through the Caribbean. Reef fisheries are extremely diverse, have many users (commercial, artisanal, recreational, and scientific), and vary greatly by location and species. Anglers fish for food, commerce, sport, and trophies. They operate from charterboats, headboats, private boats, and shore while using fish traps, hook and line, longlines, spears, trammel nets, bang sticks, and barrier nets.

Reef fish fisheries are associated closely with fisheries for other reef organisms including spiny lobster, conch, stone crab, corals, and "live" rock and ornamental aquarium species. Nonconsumptive uses of reef resources (e.g. eco-tourism, sport diving, education, and scientific research) also are economically important and can conflict with traditional commercial and recreational fisheries. Although reef fish have been caught for generations, good statistical data for most areas began in the late 1970s when recreational fishery surveys were started. Fishery data collection remains difficult because there are diverse users and landings are made at many ports. Fishing pressure has increased with growing human populations, greater demands for fishery products, and technological improvements, such as longlines, wire fish traps, electronic fish finders, and navigational aids.

Reef fisheries vary widely by area. In most cases, the current and long-term potential yields are unknown, though for many species they are probably higher than present RAYs would indicate (Table 8-1). Data are often not available by species, fishery component, or area. Statistics are confounded because species are not further identified into market categories (i.e. groupers, snappers, grunts). The reef fish management unit includes about 100 species (excluding those for the marine aquarium trade). In the southeast region, reef fisheries in the U.S. EEZ are managed by three councils (the South Atlantic FMC, the Gulf of Mexico FMC, and the Caribbean FMC). The territorial waters are managed by eight coastal states, the U.S. Virgin Islands, and Puerto Rico.

In the Gulf of Mexico, the Reef Fish FMP prohibits the use of fish traps, roller trawls, and powerheads on spearguns within an inshore

Table 8-1. Southeast Reef Fishes

Productivity in metric tons and status of fisheries resources

Area / Species	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)[2]	Long-Term Potential Yield (LTPY)[2]	Fishery Utilization Level	Stock Level Relative to LTPY
Gulf of Mexico					
Red snapper	3,215	2,780	15,000	Over	Below
Red grouper	4,638	Unknown	Unknown	Full	Near
Nassau grouper & jewfish[3]	27	0	Unknown	Over	Below
Shallow groupers (7 species)	2,516	Unknown	Unknown	Over	Unknown
Other groupers (5 species)	937	Unknown	Unknown	Unknown	Unknown
Other snappers (14 species)	5,138	Unknown	Unknown	Unknown	Unknown
Porgies (6 species)	173	Unknown	Unknown	Unknown	Unknown
Amberjacks (2 species)	2,858	Unknown	Unknown	Unknown	Unknown
Grunts (3 species)	1,546	Unknown	Unknown	Unknown	Unknown
Sea basses (3 species)	481	Unknown	Unknown	Unknown	Unknown
Others (16 species)	1,114	Unknown	Unknown	Unknown	Unknown
Atlantic					
Wreckfish	730	730	Unknown	Full	Near
Vermillion snapper	697	Unknown	Unknown	Over	Below
Red snapper	236	Unknown	Unknown	Over	Below
Red porgy	262	Unknown	450	Over	Below
Nassau grouper & jewfish[3]	11	0	Unknown	Over	Below
Other groupers (16 species)	1,465	Unknown	Unknown	Over	Below
Sea basses (3 species)	795	Unknown	Unknown	Unknown	Unknown
Other snappers (12 species)	885	Unknown	Unknown	Over	Below
Amberjacks (2 species)	1,126	Unknown	Unknown	Unknown	Unknown
Other porgies (8 species)	70	Unknown	Unknown	Unknown	Unknown
Grunts (11 species)	574	Unknown	Unknown	Unknown	Unknown
Others	1,017	Unknown	Unknown	Unknown	Unknown
Caribbean					
Nassau grouper & jewfish[3]	2	0	Unknown	Over	Below
Snappers (10 species)	255	Unknown	Unknown	Unknown	Unknown
Other groupers (6 species)	58	Unknown	Unknown	Unknown	Unknown
Grunts (5 species)	64	Unknown	Unknown	Unknown	Unknown
Others (50 species)	335	Unknown	Unknown	Unknown	Unknown
Total	31,225	30,750	43,158		

[1] 1991-93 average.
[2] LTPY is probably greatly underestimated and CPY overestimated; although production estimates are not available for most species groupes; many are probably overutilized.
[3] A total fishing prohibition has been imposed or is being considered.

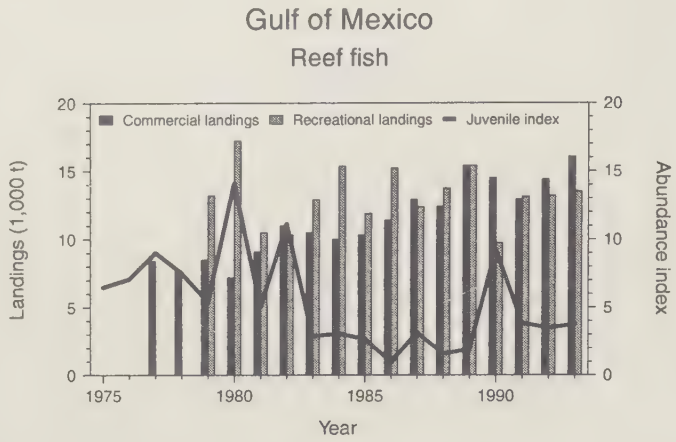


Fig. 8-1. Recreational and commercial landings of reef fish and index of abundance for juvenile red snapper.

U.S. Atlantic Reef Fish Commercial Landings (t)

1992	5,200
1993	5,100

U.S. Atlantic Reef Fish Recreational Landings (t)

1992	5,300
1993	4,100

Caribbean Reef Fish Commercial Landings (t)

1992	700
1993	800

stressed area; places a 33 cm total length minimum size limit on red snapper; and imposes data reporting requirements. A 20% spawning potential ratio was established as a basis to measure overfishing. Presently, there is a 5-fish recreational bag limit and a 1,390 t commercial quota for red snapper. For grouper, a 5-fish recreational bag limit and 4,455 t shallow-water and 727 t deep-water commercial quotas were established. Other regulations included a ban on the harvest of jewfish, a framework procedure for establishing TACs and allowing the target date for rebuilding to be changed depending on scientific information, and a revised target year of 2009 for rebuilding the red snapper stock. In 1992, a moratorium was established to stop issuing new commercial reef fish permits.

In the southern U.S. Atlantic, the Snapper-Grouper FMP emphasizes minimum size limits, bag limits, and commercial quotas. Seasonal closures exist, and the taking of jewfish and Nassau grouper are prohibited. Various gears are restricted, including a prohibition of roller trawls and fish traps (except sea bass traps). Certain commercial fishing methods are prohibited in designated special management zones around some artificial reefs. An Individual Transferable Quota (ITQ) system has been established for commercial wreckfish fishermen which is based on historic catch. It provides fishermen with a quota that can be taken any time during the season or bartered or sold to another fisherman.

In the U.S. Caribbean, the FMP for the Shallow Water Reef Fish Fishery of Puerto Rico established regulations to rebuild declining reef fish stocks in the EEZ and reduce conflicts among fishermen. It established criteria for the construction of fish traps, required owner identification and marking of gear and boats; prohibited the hauling of or tampering with another person's traps without the owner's written consent; prohibited the use of poisons, drugs, other chemicals, and explosives for the taking of reef fish; and established a minimum size limit on the harvest of yellowtail snapper and Nassau grouper. Additional regulatory amendments have been designed to protect and rebuild the stocks.

Species and Status

More than 100 reef fishes are important to commercial or sport fishermen (Table 8-1). While landings and value for individual species are not large, reef fishes overall produce significant landings and values (Fig. 8-1, 8-2, 8-3). Recent average commercial catches for the U.S. Atlantic and Gulf have been about 20,500 t with a dockside ex-vessel revenue of $48 million. Sport fishermen make more than 20 million angler-trips annually.

Reef fishes are vulnerable to overfishing owing to their long lives, slow growth, ease of capture, large body size, delayed reproduction, and other factors. Most are probably either fully utilized or overutilized (Table 8-1). Red snapper, traditionally the most important Gulf reef fish, is overutilized in part as a result of its incidental catch by the shrimp fishery. Eight of the ten major species in the Atlantic headboat fishery show significant size declines since 1972. In the Caribbean, such traditional fishery mainstays as Nassau grouper have practically disappeared, and total landings of species of more recent importance like the red hind have declined since the late-1970s. Landings of amberjack, lane snapper, vermilion snapper, and similar species have increased as catches of traditional species have declined.

Issues

Bycatch and Multispecies Interactions

Reef fish form a complex, diverse multispecies system. The long-term harvesting effects on reefs are not well understood, requiring cautious management controls of targeted fisheries as well as bycatch. Removals of apex predators from the reef complex may result in shifts of species composition. Major bycatch issues currently occur with the capture and discarding of red snapper by vessels fishing for shrimp with small-mesh nets. This bycatch problem means that, in order to meet the rebuilding goals for the stock, targeted harvests must be even more restricted. Bycatch of other species may pose similar difficulties as will the capture of undersized fish, even if they are released. The mortality rate of released fish is not well known.

Scientific Information and Adequacy of Assessments

Several stocks of reef fish are currently depleted and need to be rebuilt (e.g. jewfish, Nassau grouper). A variety of management measures need to be explored, including the use of artificial reefs and the effectiveness of marine parks and reserves to protect spawning areas.

There are a number of important scientific issues which need to be addressed to improve the advice for management. The LTPY for most of the reef fish species is unknown. Data on catch and the identification of species are inadequate for many stocks. They should be collected on a routine basis. Additional life history and biological data are needed to better understand this complex of species.

Allocation

Reef fish resources are utilized by a wide range of groups. Commercial and recreational fishermen may come into conflict with one another as well as with other users such as ecotourists. Balancing the interests of these groups is an important management issue.

Progress

An individual transferable quota system was implemented for wreckfish in April 1992. Since then, the shares are generally holding their value and fish prices have improved. ❑

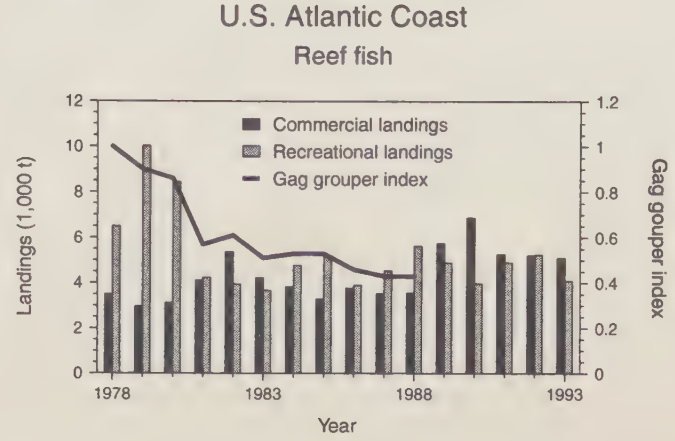


Fig. 8-2. Recreational and commercial landings of reef fish and abundance index of the Gag grouper complex.

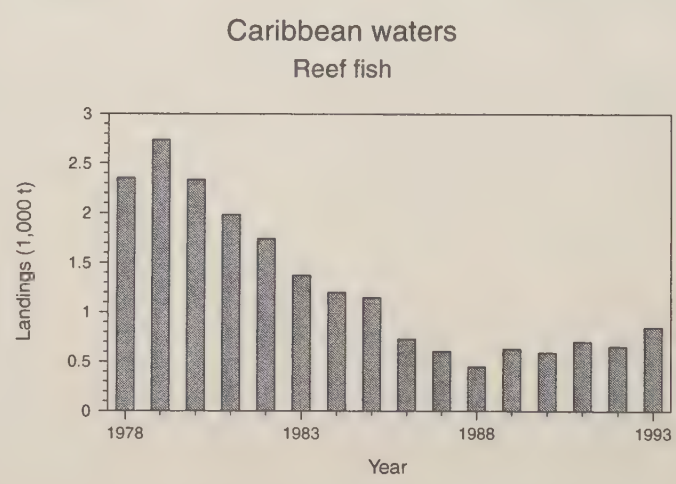


Fig. 8.3. U.S. landings of reef fish.

Gulf of Mexico Reef Fish Commercial Landings (t)

1992	14,400
1993	16,000

Gulf of Mexico Reef Fish Recreational Landings (t)

1992	13,200
1993	13,500

Unit 9

Southeast Drum and Croaker Fisheries

Introduction

Important species in this unit are the Atlantic croaker, spot, red drum, black drum, kingfishes (whiting), spotted seatrout, and other seatrouts. The drum family includes several commercially and recreationally important fishes that have been harvested since at least the late-1800s when commercial landings were first estimated. Other fisheries are much more recent. A classic example is the popularity of "blackened redfish" in the 1980s which stimulated a significant demand for red drum so that in a few years the stock became seriously depleted.

Most drum and croaker are harvested in state waters and are therefore under state management. In recent years, several states have set regulations favoring recreational use of some species, such as the red drum.

Commercial adult red drum purse seining in Federal waters of the Gulf of Mexico developed rapidly in the mid-1980s as demand grew for "blackened redfish." Before that, nearly all red drum were harvested in nearshore state waters as juveniles. But as the offshore fishery developed, it became clear that the schooling adult redfish were extremely vulnerable to heavy harvests. Analyses showed that sustainability of long-term potential yields for this fishery requires limiting the harvest of the larger adult fish. In addition, greater inshore redfish catches by recreational and commercial fishermen, complicated by other factors, have cut the number of young fish that could have replenished offshore adult stocks.

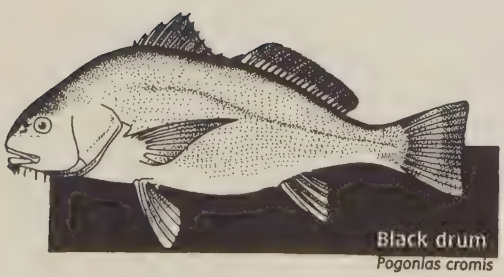
Eventually a Red Drum FMP was developed for the Gulf of Mexico and, later, for Atlantic waters. Both plans ban red drum fishing in federal waters until the adult population increases in size. This effectively bars a significant adult red drum fishery in federal waters as long as state regulations favor inshore fishing for young red drum. State actions so far have preserved inshore harvests and allocated most or all of the catch to sport fishermen.

Table 9-1. Southeast Drum and Croaker

Productivity in metric tons and status of fisheries resources

Species / Area	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)[2]	Long-Term Potential Yield (LTPY)[2]	Fishery Utilization Level	Stock Level Relative to LTPY
Black drum	2,626	Unknown	Unknown	Unknown	Unknown
Atlantic croaker	2,340	Unknown	50,000	Over	Below
Spot	2,682	Unknown	Unknown	Unknown	Unknown
Red drum					
Gulf of Mexico	3,630	3,630	7,900	Over	Below
Atlantic	597	Unknown	Unknown	Over	Below
Seatrouts	10,568	Unknown	Unknown	Unknown	Below
Kingfishes	1,990	Unknown	Unknown	Unknown	Unknown
Total	16,785	16,785	68,715		

[1] 1991-93 average.
[2] LTPY is probably greatly underestimated and CPY overestimated; although production estimates are not available for most species groups; many are probably overutilized.
[3] Grey seatrout is overfished, but other species in this group are not.



Black drum
Pogonias cromis

Species and Status

Commercial drum landings peaked in 1956 at over 32,000 t, more than 20,000 t above the 1953 level. That great increase was stimulated by development of raw material sources for the pet food industry from the northern Gulf of Mexico. Atlantic croaker was sought for pet food as well, and about 76% of the associated landings were croaker and sand and silver seatrout. This pet food catch was reported with the "industrial fishery" data after 1956, and estimates of its size and value have since been unavailable. Status and potential yields for the major species are given in Table 9-1.

The ex-vessel revenue from this group for human consumption was about $10 million in 1978. This increased to about $22 million in 1986, largely as a result of an increase in the price of the fish. The overall sport catch of these species has been about equal to the commercial harvest for human consumption (Fig. 9-1).

Observed changes in red drum mean weight of the harvest and increased incidence of

angler releases are expected results of the conservation efforts taken by the states to increase escapement rates and rebuild the spawning stock. Current statistics provide evidence that the conservation actions are having the desired effect of reducing fishing mortality on the stock. Fishery-independent sampling is underway in Texas, Louisiana and Mississippi, and the data clearly document increased survival of juvenile red drum in inshore waters. These data are supplemented by the findings of mark-recapture programs that show decreasing fishing mortality from Texas to Florida subsequent to the implementation of conservation actions by the states. In addition, the abundance of newly recruited adults has increased in recent samples of the offshore stock. All of these results suggest that conservation measures taken have substantially increased escapement of juveniles to the adult stock.

Red drum assessments are consistent with previous findings of high fishing mortality on juveniles prior to the implementation of conservation actions after about 1986. Estimates of escapement rates (the probability of surviving fishing through age 3) declined from an average of about 10% in the early-1980s to about 1% in 1986 and 1987. Estimates of escapement increased thereafter to be above 40% in 1991. If fishing mortality remains constant at the 1991 level then spawning potential ratio will reach about 20% in 1997. These estimates may be conservative depending on the causes of increased escapement rate after the low 1987-1988 estimate. These factors are currently being evaluated.

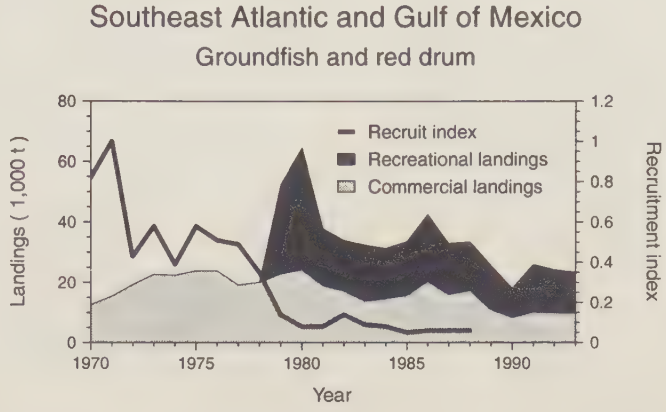


Fig. 9-1. Combined groundfish and red drum landings from SE Atlantic and red drum recruitment index for the Gulf of Mexico.

Issues

Bycatch

Bycatch of these resources in the shrimp fishery has a significant impact on their status. Large numbers of Atlantic croaker, spot, and seatrout are caught and discarded dead from shrimp trawls. As many as 500 million spot, 1 billion seatrout, and 7.5 billion croaker are discarded. These species constitute the bulk of the finfish bycatch that averaged about 175,000 t during the 1980s. NOAA Fisheries and the fishing industry have been working together to develop gear designs which will reduce the bycatch. Several promising solutions are under development. ❑

SE Groundfish & Red Drum Commercial Landings (t)

1992	9,900
1993	9,800

SE Groundfish & Red Drum Recreational Landings (t)

1992	4,400
1993	13,600

Unit 10

Southeast Menhaden Fisheries

Introduction

Menhaden are a herring-like species found in coastal and estuarine waters of the U.S. Atlantic and Gulf of Mexico. They form large schools at the surface which can be located by aircraft and harvested to produce fish meal, oil, and soluble proteins. An active baitfish fishery along the Atlantic and Gulf coasts harvests about 5% of the amount landed by the industrial fishery. These fisheries are managed by individual states, with intrastate coordination handled through the Atlantic States Marine Fisheries Commission and the Gulf States Marine Fisheries Commission (GSMFC). Menhaden are prey for many fishes and sea birds.

In the Atlantic area, the resource is fully utilized with a long-term potential yield of 480,000 t per year and a recent average yield of 330,000 t per year (Table 10-1). In the Gulf of Mexico, the menhaden resource is fully utilized with LTPY of 660,000 t and a RAY of 560,000 t.

Atlantic Menhaden

Atlantic menhaden are found from Nova Scotia (Canada) to West Palm Beach (Florida). As coastal waters warm in April and May, large surface schools form along the coasts of Florida, Georgia, and the Carolinas. The schools move slowly northward, stratifying by age and size during the summer, with the older and larger fish generally moving farther north. The southward migration begins in early fall with surface schools disappearing in late December or early January off the Carolinas. Atlantic menhaden may live 10 years, but most fish caught are 3 years of age or younger.

Menhaden landings rose during the 1940s and early-1950s, peaking at 712,100 t in 1956 (Fig. 10-1). Landings remained high during the late 1950s and early-1960s, dropped precipitously during the middle 1960s, and remained low, bottoming out at 161,600 t in 1969. Since 1970, landings have improved but not to the levels of the late-1950s. A recent peak of 418,600 t occurred in 1983, even though recruitment to age 1 is comparable with the 1950s. The commercial ex-vessel revenue of Atlantic menhaden for 1989-93 averaged $37.1 million per year. In 1994, three menhaden reduction or processing plants were in operation, two in Reedville, Virginia, and one in Beaufort, North Carolina.

The stock collapse in the 1960s drove fishing effort southward to North Carolina and Virginia where menhaden are generally younger and smaller than those in the north. Overutilization owing to "growth overfishing" (catching too many fish before they grow to full size) has been a prime management concern for this stock. While maximum spawning potential estimates have been low (10%), estimates of spawning stock biomass have rebounded from the very low levels of 1965-75, although not to the very high level of the late-1950s. A new management plan was adopted by the ASMFC in September 1992 which provided for an annual review of six "trigger" variables (landings in weight, percentage of age 0 and adults in numbers in the landings, recruits to age 1, spawning stock biomass, and maximum spawning potential). Exceeding pre-specified levels of trigger variables in conjunction with ancillary information will determine the need for specific management actions.

Gulf of Mexico Menhaden

Gulf menhaden are found from Mexico's Yucatan Peninsula to Tampa Bay, Fla. They form large surface schools that appear in the nearshore Gulf waters from April to November. Although no extensive coastwide migrations are known, some evidence suggests that older fish move

Table 10-1. Southeast Menhaden

Productivity in metric tons and status of fisheries resources

Species / Area	Recent Average Yield (RAY)	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Menhaden					
Gulf of Mexico	560,000	560,000	660,000	Full	Near
Atlantic	330,000	330,000	480,000	Full	Near
Total	890,000	890,000	1,140,000		

toward the Mississippi River Delta. Gulf menhaden may live to age 5, but most of those landed are ages 1 and 2. In 1994, active Gulf menhaden reduction plants were located in Moss Point, Miss., and in Empire, Dulac, Morgan City, Intracoastal City, and Cameron, La.

Historically, landings rose from after World War II to a peak of 982,800 t in 1984 (Fig. 10-1). Landings were generally high during the mid-1980s (greater than 800,000 t for 1982-87), but they declined steeply from 894,200 t to 421,400 t between 1987 and 1992. During this period (1987-92), the number of processing plants declined from eight to six, and vessels from 75 to 51. Although catch per unit of effort (expressed as t per vessel-ton-weeks) showed a similar decline (1.48 t/vtw in 1987 to 1.03 t/vtw in 1992, CPUE is not useful as an index of population abundance for menhaden. The commercial ex-vessel revenue of Gulf menhaden for 1989-93 averaged $51.3 million per year. Despite depressed landings during 1989-1993 that averaged 520,000 t, landings of Gulf menhaden rebounded in 1994 to 761,600 t.

Because Gulf menhaden has a short live cycle and a high natural mortality, "growth overfishing" has not been a major management concern. Management coordinated through the GSMFC consists of a 6-month fishing season (mid-April through mid-October) and closure of inside waters across the northern Gulf of Mexico. A revision to the FMP was initiated in 1993 (last revised in 1988). In fall 1992, the GSMFC recommended changing the Gulf season ending date to 1 November. Coastal states are in the process of acting on that recommendation within their regulatory framework.

Issues

Management Concerns

Atlantic menhaden continue to be growth overfished, which reduces the opportunity for greater weight production. Additionally, social concerns hav resulted in numerous area closures along the Atlantic coast. Gulf menhaden landings have declined greatly since 1988; however, estimates of maximum spawning potential remain high (about 40%).

Transboundary Stocks and Jurisdictions

Because this resource migrates long distances along the coast, interstate coordination of menhaden management is required for Atlantic menhaden along the U.S. Atlantic coast and for Gulf menhaden along the northern Gulf of Mexico through the marine fisheries commissions. Fish landed at processing plants in New Brunswick and Nova Scotia, Canada, were caught off Maine by U.S. vessels and transported to Canada for processing.

SE Atlantic Menhaden Landings (t)	
1993	320,600
1994	260,000

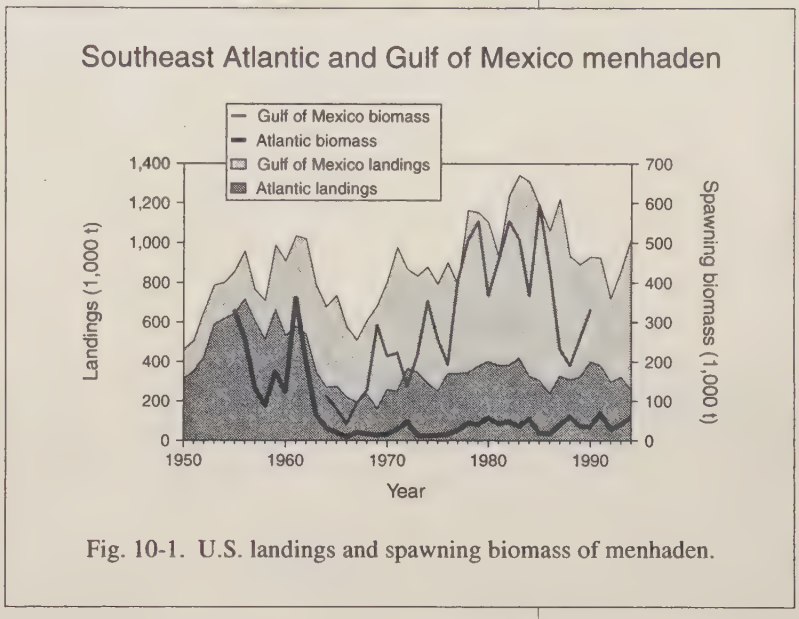


Fig. 10-1. U.S. landings and spawning biomass of menhaden.

Gulf of Mexico Menhaden Landings (t)	
1993	539,200
1994	761,600

Bycatch and Multispecies Interactions

Two Saltonstall-Kennedy studies funded in 1992 that investigated bycatch in the Atlantic and Gulf menhaden purse-seine fisheries show very low bycatch incidence (<0.1% of other species). The importance of menhaden as prey for other species should be considered with respect to multispecies resource management. ❑

Unit 11

Southeast/Caribbean Invertebrate Fisheries

Introduction

Important recreational and commercial marine invertebrates in the southeastern United States include shrimp, spiny lobster, stone crab, and conch. Some fisheries, as for coral, are almost nonexistent. Others, like the penaeid shrimp fishery, are both extensive and extremely valuable. The southeast region's shrimp fisheries are one of the most valuable U.S. fisheries based on ex-vessel revenue. Some fisheries, such as those for spiny lobster and stone crab, have only moderate value on a national basis but are important regionally. Because of the diversity in species, fisheries, geographic locations, yields, values, etc., each species group in the marine invertebrates must be examined separately for proper perspective.

Penaeid shrimp have been fished commercially since the late-1800s. The first fishery used long seines in shallow waters, until the otter trawl, introduced in 1915, extended shrimping to deeper waters. At first, most vessels towed one large trawl, sometimes 120 feet wide at the mouth. Soon, a two-trawl arrangement (each about 40-75 feet wide at the mouth) was found more effective. Some shrimpers are using a twin-trawl system which tows four trawls of about 40 feet wide at the mouth. The twin-trawl system is now very common gear on commercial offshore shrimpers.

Regulations in the Gulf of Mexico shrimp FMP restrict shrimping by closing two shrimping grounds. There is a seasonal closure of fishing grounds off Texas for brown shrimp and a closure off Florida for pink shrimp. There are also size limits on white shrimp caught in Federal waters and landed in Louisiana. These regulations strive to improve the monetary value of the shrimp fishery.

In the South Atlantic, white shrimp stocks are centered off the Georgia and South Carolina coasts. Brown shrimp are centered off the North and South Carolina coasts. The Atlantic fishery is much smaller than in the Gulf and currently is managed under a Federal FMP implemented in November 1993. This FMP provides for compatible state and Federal closures if needed to protect overwintering shrimp stocks.

Spiny lobsters are managed under a joint FMP, coordinated with regulations by the State of Florida. Current regulations specify a 3-inch minimum carapace length, a closed season from 1 April to 5 August, protection of egg-bearing females, closure of some nursery areas, recreational bag limits, and a controversial two-day "sport" season.

Caribbean spiny lobsters are caught primarily by fish traps, lobster traps, and divers. The Caribbean FMC's spiny lobster FMP includes the Federal waters of Puerto Rico and the U.S. Virgin Islands. The Federal plan is based on a 3.5-inch minimum carapace length and protection of young egg-bearing lobsters.

Table 11-1. Southeast and Caribbean Invertebrates

Productivity in metric tons and status of fisheries resources

Species	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Brown shrimp					
Gulf of Mexico[2]	54,795	Unknown	63,054	Full	Near
Atlantic	3,047	Unknown	3,696	Full	Near
White shrimp					
Gulf of Mexico[2]	30,938	Unknown	34,794	Full	Near
Atlantic	6,168	Unknown	5,173	Full	Near
Pink shrimp					
Gulf of Mexico[2]	5,427	Unknown	7,262	Full	Below
Atlantic	733	Unknown	948	Full	Near
Royal red shrimp	234	Unknown	Unknown	Unknown	Unknown
Seabob shrimp	4,442	Unknown	Unknown	Unknown	Unknown
Rock shrimp	2,146	Unknown	Unknown	Unknown	Unknown
Spiny lobster					
Southeast U.S.[3]	3,099	2,400	3,565	Over	Below
Caribbean	135	Unknown	Unknown	Unknown	Unknown
Stone crab[4]	1,264	1,121	976	Full	Near
Queen conchs[5]	55	55	Unknown	Over	Below
Coral[6]	0	0	Unknown	Unknown	Unknown
Total	112,483	111,641	95,165		

[1] 1991-93 average.
[2] Long-term potential of brown, white, and pink shrimp based upon last observed ten year average annual yield (1984-93).
[3] Yields based upon commercial catches; recreational catch is unknown but may be significant.
[4] Yields are in tons of claws; declawed crabs regnerate new claws.
[5] Landings from Puerto Rico. Fishing prohibited in Florida and U.S Virgin Islands.
[6] Coral harvests prohibited except for a small take allowed for use in aquarium and pharmaceutical industries.

The conch fishery targets the queen conch but also takes other species. Most conch are taken by divers, and the resource can be easily depleted. Conch are currently protected in state and Federal waters off Florida and in the territorial waters of the U.S. Virgin Islands. An FMP is being developed for the Federal waters off Puerto Rico and the U.S. Virgin Islands by the Caribbean FMC.

Corals are managed as two groups, hard and soft. Because they are generally slow growing and provide critical habitat for many fishes, hard corals are protected except for very small collections taken by permit for research and educational purposes. Regulations are based on the fact that the value of coral as habitat is far more important than their commercial use.

Soft corals include gorgonians and sea fans. Some gorgonians are taken (about 50,000 colonies per year) for the aquarium and pharmaceutical industries. Growth potential for most species is considered limited. Sea fans are completely protected except for research and educational use by permit.

Stone crabs are caught mainly off southern Florida, though some are landed farther north along Florida's west coast. The Gulf of Mexico stone crab FMP, approved in September 1979, generally extended Florida's regulations into the EEZ. These regulations are based on a minimum claw size of 2.75 inches, biodegradable trap panels, protection of egg-bearing females, and closed seasons. Minimum size regulations assure that crabs have reproduced at least once before being caught.

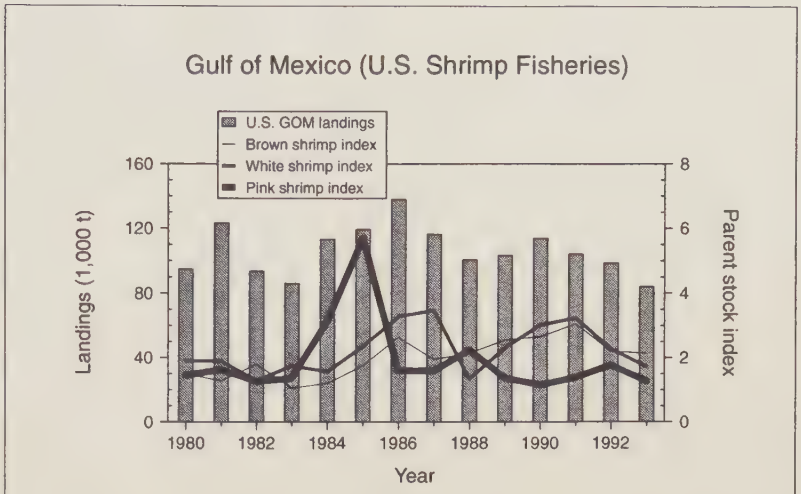


Fig. 11-1. U.S. shrimp landings and the parent stock abundance indices.

Species and Status

Shrimp Species

Brown, white, and pink shrimps account for 91% of the total Gulf of Mexico shrimp catch. In 1993 alone, these three important species produced 83,919 t valued at over $328 million in ex-vessel revenue (Fig. 11-1). They are found in all U.S. Gulf waters inside 120 m. Most of the offshore brown shrimp catch is taken at 20-40 m depths, white shrimp are caught in 10 m or less, and pink shrimp in 20-30 m. Brown shrimp are most abundant off the Texas-Louisiana coast, and the greatest concentration of pink shrimp is off southwestern Florida. In the South Atlantic, white and pink shrimp landings are about 15% of their Gulf counterparts, while brown shrimp are less than 5% of the Gulf yield. Current, recent, and long-term potential yields for these species are given in Table 11-1.

Gulf of Mexico Shrimp Landings (t)

1992	98,700
1993	84,000

Gulf brown and white shrimp catches increased significantly from the late-1950s to around 1990, with the last 3 years showing a slight decrease from these maximum values. Pink shrimp catches were stable until about 1985; then they declined and were at an all time low in 1990. In recent years the catches have started to increase and are again near average levels. The numbers of young shrimp for each species entering the fisheries have generally reflected the level of catch. All commercial shrimps are harvested at maximum levels. The fishery is believed to have more boats and gear than needed (i.e. reducing fishing effort would not significantly reduce the shrimp catch). Reducing the bycatch of the shrimp industry, however, would help protect finfish resources.

The number of young brown shrimp produced per parent has increased significantly, but not in white and pink shrimp. The brown shrimp increase appears related to marsh alterations. Coastal sinking and a sea-level rise in the northwestern Gulf inundates intertidal marshes longer, allowing the shrimp to feed for longer periods within the marsh area. In the Gulf, both factors have also expanded estuarine areas, created more marsh edges, and provided more protection from predators. As a result, the nursery function of those marshes has been greatly magnified and brown shrimp production

has expanded. However, continued subsidence will lead to marsh deterioration and an ultimate loss of supporting wetlands, and current high fishery yields may not be indefinitely sustainable. Parent stock indices for the three major Gulf species are shown in Fig. 11-1.

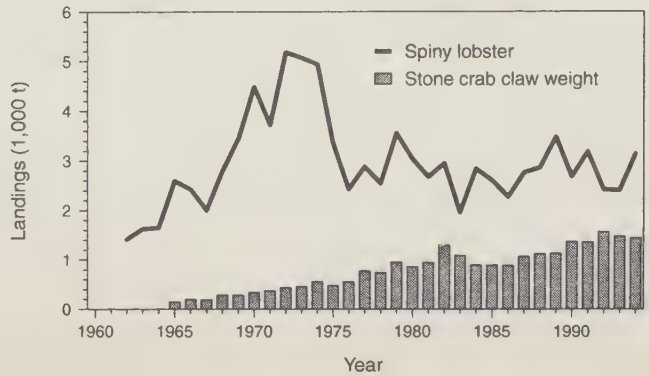


Fig. 11-2. U.S. landings of spiny lobster and stone crab.

SE U.S. Coast Spring Lobster Landings (t)	
1993	2,400
1994	3,100

SE U.S. Coast Stone Crab Landings (t)	
1993	1,500
1994	1,400

Spiny Lobster

Annual Florida spiny lobster landings were fairly stable during the 1980s, running about 2,700 t from the Gulf of Mexico (Fig. 11-2), but yielding recent high landings in 1989 of 3,200 t, with ex-vessel revenue of about $20 million. On Florida's Atlantic coast, landings have averaged 230 t, valued at $2 million. The fishery is considered "overcapitalized" with approximately 900,000 lobster traps fished during 1992. In 1993, a trap reduction program was established, not to exceed 10% per year, which would maintain or maximize sustainable spiny lobster harvest from the fishery. Excessive effort in the fishery has been estimated to occur when the number of traps fished exceeds 300,000 per year. Spiny lobster fishers utilize live undersized lobsters as attractants in their traps, but due to a high mortality rate for these "live bait" animals, about 30-50% of the potential yield is lost. The recreational fishery in Florida had over 120,000 participants purchasing recreational lobster stamps during the 1991 season. Recreational spiny lobster were estimated to comprise 41% of total landings during the first month, and 22% of the total 1991-92 season's landings.

Annual spiny lobster landings for Puerto Rico have averaged 144 t over the past 23 years, varying from 108 t in 1972 to a high of 233 t in 1979, then declining to a low of 65 t in 1988. No precise data are available on fishing effort, but the Puerto Rican stock produced landings of 72 t in 1992 and now appears to be overutilized. U.S. Virgin Islands landings for 1980-1988 were fairly stable, averaging 19 t.

Spiny lobster larvae may drift at sea for 9 months, and thus identification of their source or parent stock is almost impossible. There is a practical management need to know far more about their origin and subsequent movement into the fishery.

Stone Crab

Annual catches of stone crab (claw weight) varied from 1,200 to 1,400 t on the Gulf of Mexico and Atlantic coasts through the 1980s with a record 1,565 t landed during 1992 (Fig. 11-2). Recent annual ex-vessel revenue averaged $12-15 million. The number of stone crab traps fished seasonally increased from 295,000 in 1979-80 to 567,00 in 1984-85 to a record 745,000 during 1992-93. While total landings have increased modestly in recent years, it is clear that these landings are the result of increased effort (number of traps fished), especially during the early months of the stone crab season.

Issues

Habitat Concerns

Estuarine and marsh loss remove critical habitat for young shrimp. Additional studies are needed to further assess the impacts of human-induced changes in habitat availability, environmental conditions, predator abundance, and pollution in the nursery areas. Florida spiny lobsters depend on reef habitat and shallow-water algal flats for feeding and reproduction. These habitat requirements may conflict with expanding coastal developments. The productivity of stone crabs in Florida Bay is related to water quality and flow through the Everglades. Specific water requirements need to be identified and maintained through comprehensive Ever-

glades water management. A unified program to integrate and study the effects of environmental alterations, fishing technology, regulations, and economic factors on shrimp, lobster, and crab production and restoration is needed, particularly in the reef habitats of south Florida. Steps need to be taken to mitigate or restore lost estuarine habitats.

Transboundary Stocks and Jurisdiction

Spiny lobster stocks in Florida could be of Caribbean origin and swept into the region by currents of the Gulf Stream. Another hypothesis is that they could comprise a number of different spawning stocks. The actual sources of all Florida and Caribbean lobster stocks (both U.S. and foreign) need to be identified and international management established to prevent overharvesting.

Management Concerns

Many small spiny lobsters are caught in the Puerto Rican fishery. If these lobsters were allowed to grow to a larger size before harvest, there would be a substantial increase in yield by weight. Modification of the traps to allow more of the small lobsters to escape needs to be investigated. Small lobsters are sometimes used to bait traps in the lobster fishery. This current practice is wasteful and hinders rebuilding of the stock.

The shrimp fisheries are currently overcapitalized, with more fishing effort being expended than needed to harvest the resource. In addition, the harvesting of small shrimp inshore is sacrificing yield and value of the catch by cutting short future growth.

Bycatch and Multispecies Interactions

Shrimp fisheries use small-mesh nets and can catch nontarget species such as red snappers, croakers, seatrouts, and sea turtles. For finfish, this harvest is often of juveniles and may be a major source of mortality on these young fish. Some fish caught by shrimpers are currently at low stock levels (Unit 9). This bycatch may slow or prevent recovery if not mitigated.

As sea turtles are all listed as endangered or threatened under the ESA, shrimp vessels have been required to use turtle excluder devices in their nets during certain times of the year since 1988 to avoid capturing sea turtles and thus protect the stocks.

Progress

NOAA Fisheries and the fishing industry are working together to prepare a research plan to address the problems of finfish bycatch by shrimp fisheries in the Gulf of Mexico and South Atlantic.

A gear conflict between stone crab trappers and shrimp trawlers off southwestern Florida has been mostly resolved in the EEZ with a line separating the fishing areas and seasonal area closures. This approach requires continued monitoring to gauge its success and prevent renewal of conflicts. ❑

Unit 12

Pacific Coast Salmon

Introduction

Pacific salmon support important traditional commercial and recreational fisheries in Washington, Oregon, and California. Salmon are part of the culture and heritage of the Pacific Northwest; having been harvested by native Americans for millennia.

Pacific salmon are anadromous. They spawn in freshwater and migrate to the ocean where they may undergo extensive migrations. At maturity, they return to their home stream to spawn and complete their life cycle.

Table 12-1. Pacific Coast Salmon

Productivity in metric tons and status of fisheries resources

Species	Recent Average Yield (RAY)[1,2]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Chinook	4,783	11,460	11,460	Over	Below
Coho	2,459	5,300	5,300	Over	Below
Pink	5,743	7,270	7,270	Full	Near
Sockeye	4,231	4,646	4,646	Full	Near
Chum	5,741	4,636	4,636	Full	Near
Total	22,957	33,312	33,312		

[1] Recent average is for 1992-94 except for pink salmon which is 1989-91-93 average.
[2] Recreational harvest was converted from numbers of fish to approximate weight using average weights of salmon caught in commercial fisheries from 1990-94: Chinook = 5.04 kg, coho = 2.48 kg, pink = 2.08 kg, sockeye = 2.60 kg, and chum = 4.59 kg.

Pacific salmon include five species: chinook, coho, sockeye, pink, and chum salmon. Chinook and coho salmon are harvested recreationally and commercially in the Pacific Ocean, Puget Sound, and in freshwater rivers on their spawning migrations. All recreational fisheries use hook-and-line gear. Commercial fisheries use a variety of gear depending on location: in the Pacific Ocean all harvest is by trolling; in Puget Sound, gillnets and purse seines are also used; gillnets are used almost exclusively in freshwater and estuaries. Pink, chum, and sockeye salmon are not harvested in significant numbers recreationally nor outside of Puget Sound, although there are recreational fisheries directed at these species in a few locations. The majority of harvest is by commercial gillnet and purse seine fisheries in Puget Sound and gillnet fisheries in estuaries. All species are also harvested by Native American tribes for subsistence and ceremonial purposes.

From 1992-94, the average annual commercial salmon catch (15,000 t) provided revenues averaging over $30 million at dockside. Recreational catches are more difficult to value since the recreational experience associated with the catch cannot be easily measured. If recreationally caught fish are valued at a conservative $20 per fish, the 1992-94 average catch of 850,000 fish would have been worth about $17 million annually.

The abundance of individual stocks of Pacific salmon, and the mixture of stocks contributing to fisheries fluctuate considerably. Consequently, landings fluctuate. For all species, there is excess fishing power and overcapitalization of the fishing fleets. While harvest rates in recent years have been held near, or below, levels that would produce the long-term potential yield, environmental conditions have resulted in poor production of chinook and coho salmon in general and some individual stocks of other species. Because of the depressed status of chinook and coho salmon, these two species are considered overexploited while the other species are considered fully exploited (Table 12.1).

Management Situation

The management of this resource is complex, involving many stocks originating from various rivers and jurisdictions. Ocean fisheries for chinook and coho salmon are managed under an FMP by the Pacific FMC with the cooperation of the states and tribal fishery agencies. Within Puget Sound and the Columbia River, fisheries for these two species are managed by the states and tribes. The other three species (pink, chum, and sockeye salmon) are managed primarily by the Pacific Salmon Commission (PSC), the state of Washington, and tribal fishery agencies.

Fishery impacts are managed using a variety of regulations. Ocean fisheries are managed primarily by gear restrictions, minimum size limits, and time and area closures; although harvest quotas have been placed on

individual fisheries in recent years. Fisheries managed by the PSC have used harvest quotas based on inseason abundance forecasts. Some commercial fisheries in the Columbia River have used inseason monitoring of cumulative impacts to sensitive stocks based on genetic analysis of the catch to close the fisheries.

Because Pacific salmon depend on freshwater habitat for reproduction and rearing areas and the quality of freshwater habitat is directly influenced by land management practices, salmon production is heavily influenced by entities not directly involved in the management of fisheries. Salmon management involves the cooperation of the U.S. Forest Service, Bureau of Land Management, Fish and Wildlife Service, Bureau of Reclamation, Army Corps of Engineers, Environmental Protection Agency, Bonneville Power Administration, state resource agencies, Indian tribes, municipal utility districts, agricultural water districts, private timber companies and landowners.

On September 12, 1994, in response to an increasing number of petitions to list various populations of Pacific salmon and anadromous trout as endangered species, NOAA Fisheries announced its intent to conduct comprehensive, coastwide status reviews of all species of Pacific salmon. These status reviews are in various stages of completion.

Resource Status

Chinook salmon

Chinook salmon are produced primarily by rivers and hatcheries in Puget Sound in Washington, the Columbia River, the Umpqua and Rogue Rivers in Oregon, and the Klamath and Sacramento Rivers in California. Chinook salmon stocks are named for the season in which they migrate from the ocean to freshwater to spawn, and include spring, summer, fall and winter runs. The proportion of chinook salmon production originating from hatcheries has been increasing.

Chinook salmon production tends to fluctuate considerably (Fig. 12-1) depending on habitat conditions in freshwater and on ocean productivity. In recent years, problems with freshwater habitat have been exacerbated by drought in many areas in the west, and ocean conditions have been generally unfavorable for chinook salmon since the late-1970s. This has resulted in historically low levels of a number of stocks and commercial and recreational catches. Currently, the Snake River spring/summer run has been listed as a threatened species, and the Snake River fall-run and the Sacramento River winter-run chinook salmon populations have been listed as endangered species by NOAA Fisheries. In addition, several other runs from all parts of the coast have failed to meet their escapement goals in recent years. Concern for the status of depressed stocks has led to increasingly restrictive ocean fishing seasons in recent years.

Pacific Coast Chinook Commercial Landings
(Number of Fish)

1993	608,000
1994	463,000

Pacific Coast Chinook Recreational Landings
(Number of Fish)

1993	315,000
1994	452,000

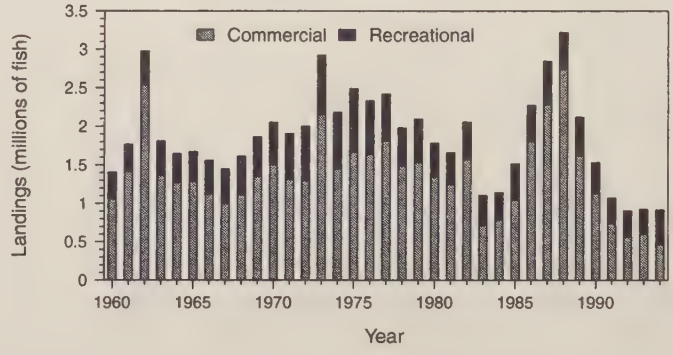


Fig. 12-1. Chinook salmon landings from the combined Washington, Oregon, and California region.

Coho Salmon

Coho salmon are produced primarily by rivers and hatcheries in Puget Sound in Washington, hatcheries in the Columbia River and coastal rivers and hatcheries in Oregon and California. Hatcheries play a larger role in the production of coho salmon than in the case of chinook salmon, in some areas accounting for over 80% of the catch. Recent reductions in landings have resulted from record low abundances of several stocks of coho salmon including Oregon coast and Columbia River hatchery stocks Fig. 12-2). To protect the spawning escapement of these stocks and to provide fish for the legally-mandated tribal

allocation, severe restrictions were placed on ocean fisheries in 1993 and 1994. In May 1994, retention of coho salmon was prohibited in all ocean fisheries.

Pacific Coast Coho Commercial Landings
(Number of Fish)

1993	331,000
1994	532,000

Pacific Coast Coho Recreational Landings
(Number of Fish)

1993	430,000
1994	550,000

Sockeye, Pink and Chum Salmon

Pink and chum salmon originate primarily from tributaries of Puget Sound, Washington. Chum salmon are also produced, in limited numbers, in the Columbia River and coastal streams as far south as central Oregon. Sockeye salmon originate from river systems that contain lakes. They are produced in a few rivers in Puget Sound and in limited numbers in a few coastal rivers on the Olympic Peninsula and in the upper Columbia and Snake River basins. The majority of the harvest of these species is caught commercially in the Puget Sound region of Washington. Much of the U.S. harvest of sockeye and pink salmon originates from the Fraser River in Canada. Though Fraser River runs have been large in recent years, the U.S. catch has been limited under the Pacific Salmon Commission. Historical landings of the species are shown in Figs. 12-3 and 12-4.

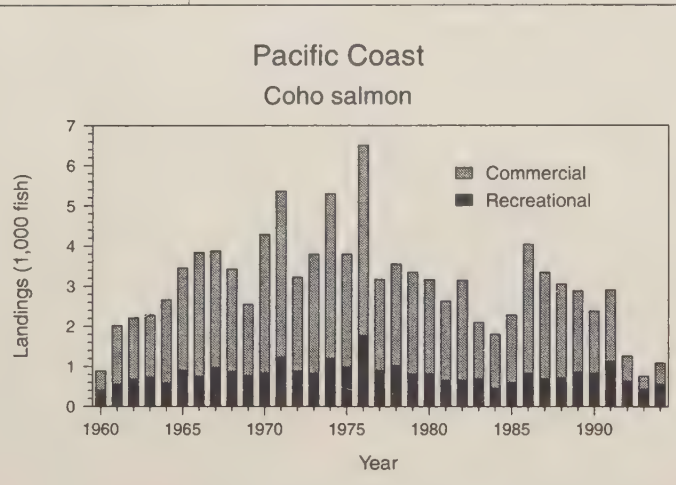


Fig. 12-2. Coho salmon landings from the combined Washington, Oregon, and California region.

Pacific Coast Sockeye Landings
(Number of Fish)

1993	2,426,000
1994	1,861,000

Recreational Fisheries

Pacific salmon support valuable recreational fisheries in saltwater, freshwater, and in estuaries. Recreational landings of chinook salmon have averaged about 350,000 fish annually for the period 1992-94. During the same period recreational landings of coho salmon have averaged about 460,000 salmon from hatchery and natural production combined. These represent substantial reductions from recreational landings in the recent past, especially for coho salmon which had recreational landings averaging 864,000 salmon in the period 1990-92.

These reduced landings reflect lower abundance of these two species. Restrictive fishing seasons to protect depressed stocks of coho salmon and chinook salmon stocks listed under the Endangered Species Act have reduced the overall harvest of chinook and coho salmon. The depressed status of chinook and coho stocks has not been reflected in lower angler success rates in recreational fisheries. More severe reductions in commercial fisheries have largely compensated for reduced abundance by increasing the availability of chinook and coho salmon to recreational anglers.

Recreational landings for sockeye, pink, and chum salmon combined have consistently been under 100,000 fish, and have averaged about 80,000 fish. Recreational landings of these species are much lower than recreational catches of chinook and coho salmon while commercial landings are substantially greater. The reason for this discrepancy lies in the life histories and migration patterns of the individual species. Sockeye, pink and chum salmon migrate far offshore into the central North Pacific Ocean and the Gulf of Alaska. Consequently they are only available to recreational fisheries briefly during their spawning migration. In addition, pink and chum salmon spawn and die shortly after entering freshwater as adults. By the time they reach terminal areas where recreational fisheries are located, they have undergone physiological changes in preparation for spawning. Consequently, their flesh is of poorer quality, and they are not as highly prized as chinook, coho and sockeye salmon. While the recreational fisheries for sockeye, pink, and chum salmon are substantially smaller than recreational fisheries for chinook and coho salmon, they are still important.

Landings

For the period from 1992-94, the chinook salmon harvest from natural and hatchery production combined averaged about 550,000 fish. In the same period, commercial catch of coho salmon has averaged about 500,000 salmon This is a substantial reduction from the 1990-92 average commercial landings of 815,000 chinook salmon and 2,180,000 coho salmon, and as with recreational landings, reflects restrictions placed on ocean fisheries in 1993 and 1994 to protect the spawning escapement of depressed and listed stocks.

Sockeye, pink and chum salmon have not suffered the same recent declines as chinook and coho salmon. Trends in the recent landings have generally been stable or increasing. Recent average annual catches of these species were roughly 1.6 million sockeye salmon (1992-94), 1.3 million chum salmon (1992-94), and 2.6 million pink salmon (1989, 91, 93).

Issues and Progress

Balancing Competing Users

The decline in chinook and coho salmon abundance has forced severe reductions and closures of ocean fisheries in recent years. These reductions, in some cases, follow earlier reductions legally mandated to allocate salmon to inside fisheries for harvest by Native American tribes. These ocean fisheries cannot redirect their effort to take advantage of abundant sockeye, pink , and chum salmon stocks, because the ocean distribution of these species keeps them outside the range of coastal fisheries. With the prospect of even further restrictions that may be required to protect threatened and endangered species, the future viability of these fisheries is in doubt.

Hatchery versus Wild

The use of hatcheries to mitigate habitat loss and to enhance fisheries, especially for chinook and coho salmon, has raised concerns about the interactions of hatchery and natural fish. While hatchery fish can supplement natural production, they can also compete with naturally produced fish. In areas where fisheries are managed for hatchery production, harvest rates may be higher than the natural stocks can sustain. In addition, some hatchery fish fail to return to the hatchery and would attempt to spawn in the wild with native fish. Hatchery fish are often of non-native origin, and the introgression of non-native genes into natural populations can compromise the genetic integrity of the native stocks and decrease their productivity. To address these concerns, NOAA Fisheries has drafted an interim policy on artificial propagation in the listing and recovery of Pacific salmon under the ESA.

Pacific Coast Chum Landings
(Number of Fish)

1993	957,000
1994	1,323,000

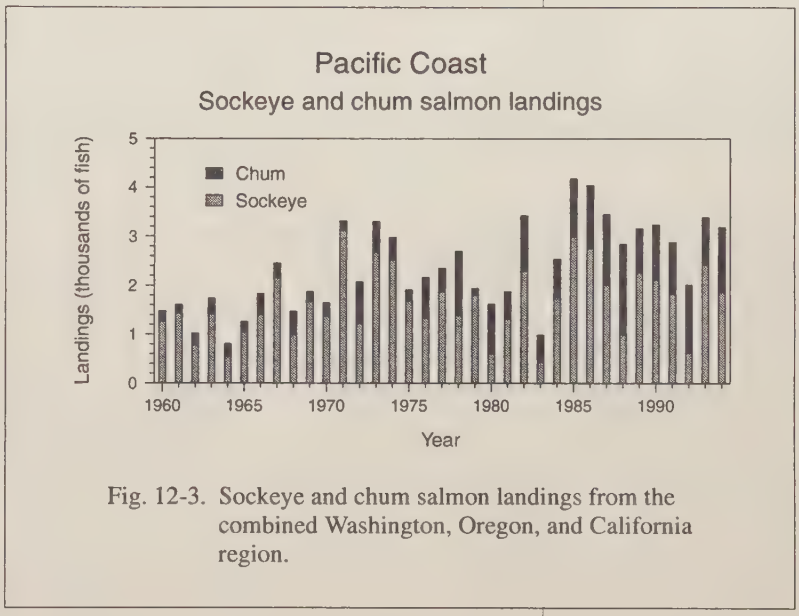


Fig. 12-3. Sockeye and chum salmon landings from the combined Washington, Oregon, and California region.

Bycatch and Multispecies Interactions

Some salmon, primarily chinook, are caught incidentally in the Pacific whiting fishery. While the numbers are small, this is a sensitive issue when directed salmon fisheries have been increasingly restricted. Interactions with marine mammals have also become a sensitive issue as populations of California sea lions have increased. Predation by sea lions tends to be localized, but is also highly visible.

Transboundary Stocks and Jurisdiction

Because salmon migrate long distances, they are subject to interception by fisheries distant from their region of origin. Issues of allocation have never been easy to resolve and have been addressed in a variety of forums. The

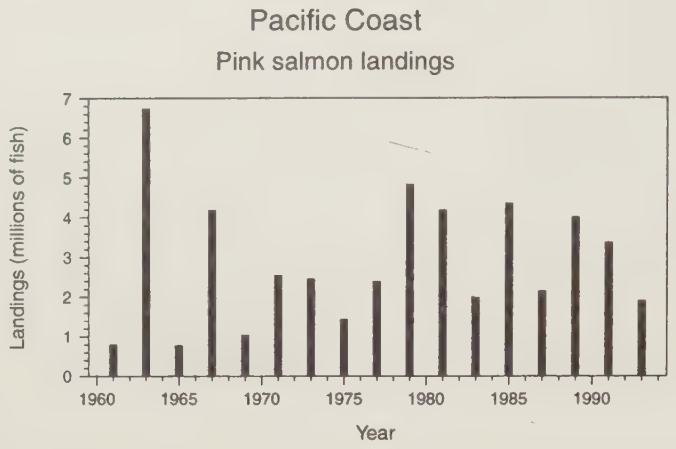


Fig. 12-4. Pink salmon landings from the combined Washington, Oregon, and California region.

Pacific Coast Pink Landings
(Number of Fish)

1989	4,000,000
1991	3,373,000
1994	1,894,000

Pacific Salmon Commission has been set up to address the allocation of salmon between the U.S. and Canada. In 1994, a breakdown of the negotiations led to aggressive harvesting that compounded forecasting errors and nearly destroyed one of the most productive runs of sockeye salmon from the Fraser River in British Columbia. Much of the annual process of managing ocean salmon fisheries by the Pacific FMC is concerned with the allocation of fish between ocean and inside fisheries, commercial and recreational fisheries, and tribal and non-tribal fisheries. The allocation of salmon between Native American tribes and non-tribal users continues to be defined in federal courts.

Ecosystem Considerations

The abundance and harvest of coho salmon reached a peak in 1976, and has declined since then. Chinook salmon abundance has also generally declined since the mid-1970s, although there was a brief increase in chinook salmon abundance in the late-1980s. This decline has affected both hatchery and natural stocks, and seems to indicate a decline in ocean survival. This decline is coincident with a change in the oceanographic regime off the west coast that occurred around 1978. Since then, the coastal waters off California, Oregon, and Washington, where many chinook and coho salmon stocks rear, have been warmer and less productive than they were in the period from roughly 1950-78. This decline in ocean productivity off the Pacific coast appears to be linked to increased productivity in the Gulf of Alaska. Sockeye, pink and chum salmon, which migrate further offshore than chinook and coho salmon, have been relatively stable or increasing during the same period that chinook and coho salmon have declined.

Because Pacific salmon depend on freshwater habitat for spawning and juvenile rearing, they are particularly vulnerable to habitat degradation caused by human impacts. Throughout their range, their habitat has been degraded by logging, agriculture, grazing, and urbanization. Water development for hydropower, irrigation, and municipal and domestic uses directly competes with salmon for the freshwater on which they depend. As the human population in the western U.S. continues to increase, so will the pressures on salmon habitat. The fact that we still have salmon in harvestable quantities is a tribute to the resilience of these fish. ❑

Alaska Salmon

Introduction

Salmon are important to Alaska's native culture and heritage. Salmon also provide increasing recreational and business opportunities in sport fishing to residents and visitors. Today, Alaska's rich abundance of Pacific salmon yields record harvests to fisheries that provide the state's largest nongovernmental source of employment.

Alaska salmon catches have been on a general increase (Fig. 13-1). After the depressed stock levels in the 1970s, most populations have rebuilt to high levels. The all-time peak catch of 196 million fish was taken in 1994. Sport and subsistence harvest of salmon totaled over 1 million fish in all waters in 1992. Recreational harvest is now 24% above the 1982-1991 average. The large hatchery program begun in 1974 by Alaska now provides 35 million salmon to the commercial catch, primarily in pink and chum salmon.

The value of the 1994 statewide catch (391,800 t) has been estimated at $427 million (ex-vessel value). This is slightly higher than the $390 million ex-vessel value of the 1993 harvest but down from the $575 million for the 1992 season.

Several factors contribute to the high abundance of salmon. These include: (1) informed management by State and Federal agencies; (2) extant pristine habitats; (3) elimination of high-seas driftnet fisheries; (4) reduction of bycatch; (5) hatchery production; and (6) favorable ocean rearing conditions.

Alaska's 34,000-mile coast is nearly two-thirds the length of the coastline of the "lower 48" states. Along this coastline, over 14,000 water bodies support salmon populations. Salmon management in such a vast area requires a complex mixture of domestic and international bodies, treaties, regulations, and agreements. Federal and state agencies participate in their management. The Alaska Department of Fish and Game (ADF&G) manages all fisheries in state waters where the majority of harvest occurs. Management in the EEZ is the responsibility of NOAA Fisheries and the North Pacific FMC.

Salmon management is also negotiated with Canada through the Pacific Salmon Commission. Recent U.S. and Canada negotiations stalled when agreement was not reached on the catch allocations needed in northern fisheries under the Pacific Salmon Treaty. In particular, major disagreements arose over chinook salmon catches in SE Alaska where Canadian salmon are caught along with U.S. stocks.

Table 13-1. Alaska Salmon

Productivity in metric tons and status of fisheries resources

Species	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)[2]	Fishery Utilization Level	Stock Level Relative to LTPY
Pink	138,400	119,700	119,700	Full	Above
Sockeye	151,300	114,200	114,200	Full	Above
Chum	43,900	39,400	39,400	Full	Near
Coho	26,100	17,600	17,600	Full	Above
Chinook	5,100	5,600	5,600	Full	Below
Total	364,800	296,500	296,500		

[1] 1992-94 average.
[2] 1980-94 average.

On a broader international scope, the management of salmon in the high seas of the North Pacific Ocean from 1957 to 1992 was authorized by the International North Pacific Fisheries Commission (INPFC), and via bilateral and multilateral talks and negotiations with Taiwan and the Republic of Korea. In 1993, the North Pacific Anadromous Fish Commission (NPAFC) was formed to replace INPFC. This Commission of four countries (Canada, Japan, the Russian Federation, and the United States) now provides a framework for international cooperation in salmon management and research in the North Pacific Ocean. The NPAFC Convention clearly prohibits high seas salmon fishing and trafficking of illegally caught salmon. Coupled with United Nations General Assembly (UNGA) Resolution 46/215, which bans large-scale pelagic driftnet fishing in the world's oceans, salmon harvesting in the high seas should cease, and management control can return to the salmon-producing nations.

Species and Status

Pacific salmon are anadromous species that spend a portion of their life (1-7 years) at sea and return to freshwater streams to spawn and die. From their freshwater spawning grounds, the young salmon migrate to nearshore rearing areas and may migrate thousands of miles out to sea outside of the U.S. EEZ before returning to natal waters to spawn.

Alaska Salmon Landings
(Number of Fish)

1993	193,000,000
1994	196,000,000

Alaska's five salmon species (chinook, coho, chum, sockeye, and pink) are fully utilized, and stocks generally have rebuilt to or beyond previous high levels (Table 13-1). Research has been extensive into all aspects of the salmon's life history, and the information has been used to regulate fisheries on stocks by monitoring escapement size and catch numbers by season and area. The unprecedented recent high catches should not be interpreted as an absence, in Alaska, of the same factors affecting declines of salmon in the Pacific Northwest. Problems associated with overfishing, incidental take as bycatch in other fisheries, and loss of spawning and rearing habitat in freshwater and nearshore ocean areas are also present in the Alaska region.

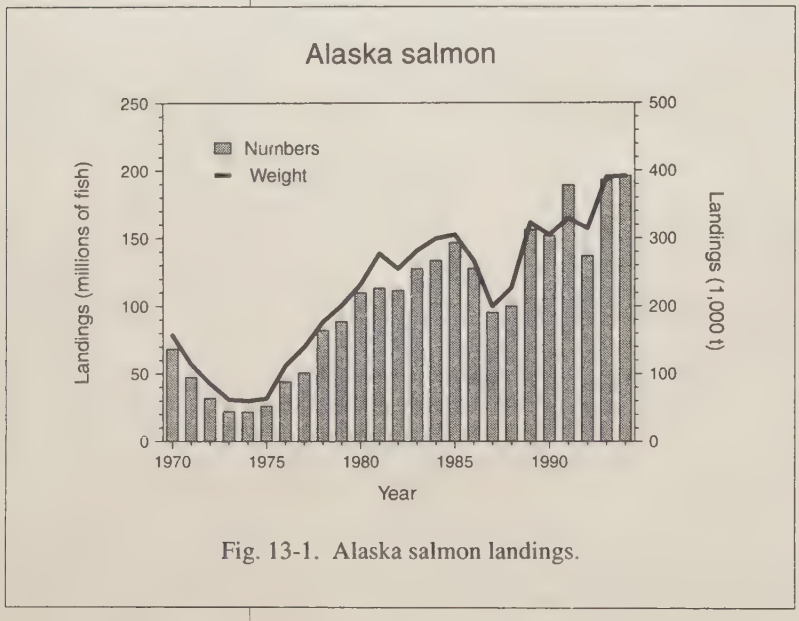


Fig. 13-1. Alaska salmon landings.

Alaska Salmon Landings (t)

1993	389,700
1994	391,800

Issues

Bycatch and Multispecies Interactions

Bycatch of salmon by U.S. groundfish fisheries in the Bering Sea and the Gulf of Alaska remains a problem in groundfish management. About 60,000 chinook salmon were taken incidentally each year between 1992 and 1994 in these trawl fisheries. In that same period, about 173,000 other salmon per year were taken as trawl bycatch. The problem is currently being addressed by the North Pacific FMC through time-area closures and bycatch limits set for the groundfish fisheries.

Habitat Degradation

Responsible management of Alaska's salmon resource is a national responsibility shared between the state and federal government. Maintaining this renewable resource requires considered and planned use for thousands of miles of riparian habitat that support salmon production. Competing uses for this habitat include logging, mining, oil and gas development, and industrial and urban development. Although progress has been made in setting Federal and State land use guidelines, conflicts still occur. Natural resource managers continually face increasing demands from extractive industries to log, drill or fill on riparian habitats while working to change land use laws. An example is the continuing debate over the required size of clear cuts and buffer zones along anadromous fish streams. In its recent review of timber harvest in the Tongass National Forest, the U.S. Forest Service concluded that long term application of current timber harvest procedures could lead to, or continue, declines in habitat productivity and eventual loss of salmonid stocks. The recent buy-back of Federal gas and oil leases in Bristol Bay is another example of long-term protection granted to the salmon resource.

Hatchery Enhancement

Alaska's salmon enhancement program produces significant numbers of fish for commercial and sport harvest. While most hatcheries are now operated by the private sector, the State manages fisheries to minimize catches of wild fish where large numbers of returning hatchery salmon are caught. Overfishing is particularly a

concern where wild stocks are in low abundance and spawning escapement goals may not be achieved. One area of concern is Prince William Sound (PWS) where large returns of hatchery pink salmon mix with much lower numbers of wild fish. State managers are particularly concerned because wild stocks in Prince William Sound continue at low abundance.

Progress

Significant progress has been made to control the interception and incidental take of Alaska's salmon resources. First, a formerly legal high-seas salmon fishery by Japan, which was authorized by an international Convention from 1952-1992, was terminated under a new Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean. Second, high seas driftnet fisheries for squid by various countries that also intercepted U.S.-origin salmon stocks in the central North Pacific Ocean have been terminated by United Nations General Assembly Resolution 46/215. A remaining problem of salmon bycatch in U.S. groundfish fisheries in the Bering Sea and the Gulf of Alaska is actively being managed by the North Pacific FMC through time-area closures and bycatch limits set for the groundfish fisheries. Negotiations continue with Canada, in the Pacific Salmon Commission, to resolve long-standing interception issues, particularly in the northern British Columbia and Alaska boundary area. Natural resource managers in Alaska are dealing with increasing demands of industrial developments while working to maintain the productive natural habitats that support Alaska's wild salmon. To assist in meeting the need for better understanding wild stock status, a cooperative effort has begun in SE Alaska between ADF&G and the Alaska Chapter of the American Fisheries Society which will provide a population status inventory of the state's salmon and steelhead resources. ❑

Coho salmon
Oncorhynchus kisutch

Unit 14

Pacific Coast and Alaska Pelagic Fisheries

Introduction

Several stocks of small pelagic fish species support fisheries along the Pacific coast. The major ones are Pacific sardine, northern anchovy, jack and chub (Pacific) mackerel, and Pacific herring. Sardine, anchovy, and mackerel are primarily concentrated and harvested off California and Baja California. Pacific herring are taken along the west coast from California to Alaska.

Sardine and anchovy are the most prominent of the fisheries from a historical perspective. These small pelagic species, like Peruvian anchovy and Japanese sardine, tend to fluctuate widely in abundance. The California sardine fishery was the largest fishery in the western hemisphere during the 1930s and early-1940s when total catches averaged 500,000 t. Its abundance and catches declined after World War II (Fig. 14-1), and the stock finally collapsed in the late-1950s. In the mid-1940s, U.S. processors began canning anchovies as a substitute for sardine. Consumer demand for canned anchovies, however, was low and catches from the mid-1940s to mid-1950s averaged only 50,000 t. Catches declined and remained low before starting to increase in 1965. Together with catches from Mexico, the total catch increased to 350,000 t during 1975-80. Thereafter, U.S. catches declined due mainly to significant price reductions for fish meal. Low prices and market problems continue to prevent a significant U.S. reduction fishery for anchovies in recent years. The other small pelagic species also have a tendency to fluctuate widely in abundance.

All these pelagic fishery resources are under active management. The anchovy fishery is managed under the Northern Anchovy FMP by the Pacific FMC. Pacific sardine, Pacific herring, and chub mackerel are managed by the State of California. Jack mackerel north of lat. 39°N are managed under the Pacific Coast Groundfish FMP.

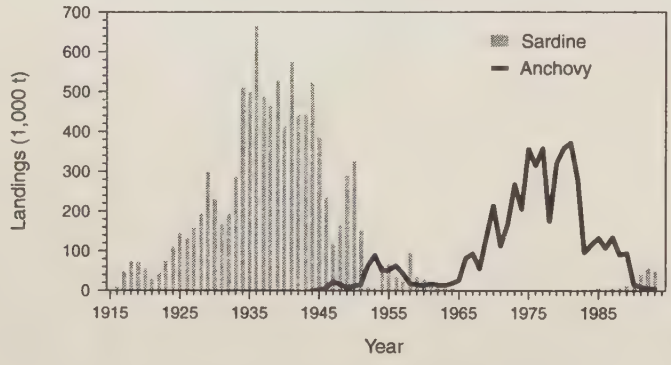


Fig. 14-1. Succession of species landings of Pacific sardine and northern anchovy.

Table 14-1. Pacific Coast and Alaska Pelagics

Productivity in metric tons and status of fisheries resources

Species	Recent Average Yield (RAY)	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Pacific Coast					
Pacific sardine[1]	19,000	22,000	250,000	Full	Below
Northern Anchovy[1]	6,000	7,000	120,000	Full	Near
Jack mackerel	9,000	53,000	100,000	Under	Near
Chub mackerel[1]	24,000	23,000	28,000	Full	Below
Pacific herring	5,900	Unknown	Unknown	Full	Below
Alaska					
Pacific herring					
Gulf of Alaska	22,600	15,900	Unknown	Full	Near
Bering Sea	30,300	39,300	Unknown	Full	Near
Total	116,800	166,100	559,100		

[1] Mexican catches are typically as large or larger than U.S. catches, but are not included in RAY.

Species and Status

Pacific Sardine

California sardine abundance has gone through boom and bust cycles (Fig 14-2). The decline of the resource, from a biomass of more than 3 million t in the 1930s to unmeasurable low levels (a few hundred t) in the 1970s, stimulated much debate as to whether fishing or an adverse natural environmental period was to blame. In retrospect, the intensive fishing pressure on the resource at that time probably

accelerated a long-term pattern of natural decline. The biomass of sardines remained negligibly low for about 40 years. Since 1986, sardine biomass has increased by 30–40% per year and quotas have been allowed for commercial fishing. The biomass is currently 100,000–300,000 t.

In the past, sardines were harvested for fish meal, bait, and human consumption. Currently, there is no fish meal (reduction) fishery. Sardines are now taken for human consumption and bait. Commercial demand for sardines is strong and, as resource abundance grows, the fishery is expected to revive.

The sardine resource is recovering but remains at low abundance. Current potential yield is only 22,000 t or less than 9% of LTPY (Table 14-1).

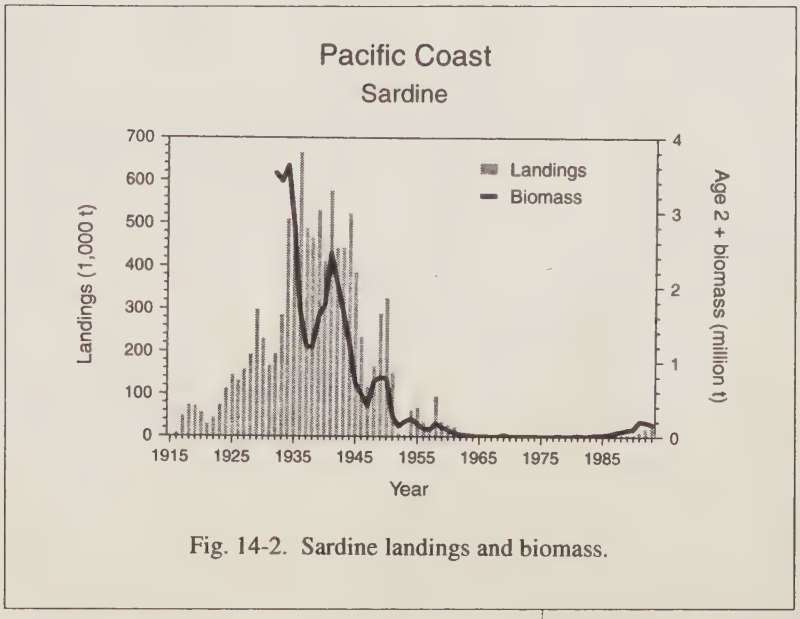


Fig. 14-2. Sardine landings and biomass.

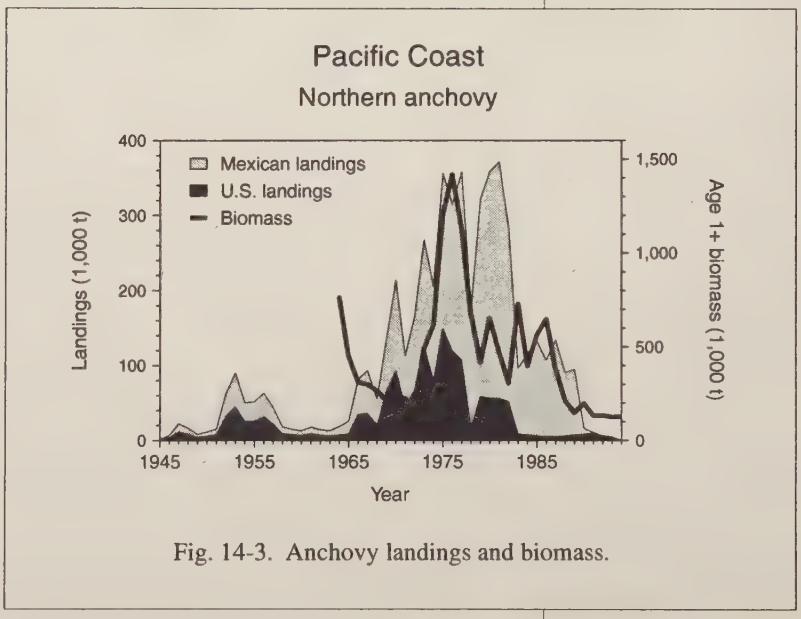


Fig. 14-3. Anchovy landings and biomass.

Northern Anchovy

Northern anchovies are fished off California and Mexico. The "central subpopulation" of the resource is the one that supports most of the U.S. fisheries. Anchovies are harvested for reduction into fish meal, oil, and soluble protein products. Other catches are used for human consumption (fresh, frozen, canned, and paste), and as bait (live and frozen) for recreational fisheries.

Anchovy landings in California have fluctuated more in response to market conditions than to stock abundance. Figure 14-3 shows the historical trend of catches by the U.S. and Mexico. Landings by the U.S. have varied from less than 10,000 t to nearly 140,000 t. Since 1983, U.S. landings have been low (less than 10,000 t), and have been used mostly for live bait and other nonreduction uses. The biomass trend for the anchovy resource is also shown in the figure. The biomass in recent history peaked at 1.4 million t in 1985 and has declined steadily to 126,000 t by 1994.

The well-being of ecologically-related species in the ecosystem is an important factor in management of the anchovy resource. The endangered Brown Pelican, for example, depends on anchovies as an important food source. Thus, the anchovy FMP has specified a threshold for its optimum-yield determination to prevent anchovy depletion and provide adequate forage for marine fishes, mammals, and birds.

The anchovy resource is presently low in abundance. Current potential yield is only 7,000 t or less than 6% of LTPY (Table 14-1). No numerical limit has been placed on the live-bait catch in the United States on account of its small catch, but there is a 7,000 t quota for other nonreduction uses.

Jack Mackerel

Jack mackerel catches fluctuated widely with changing market demand and the ability of the fleet to fish for other species which were more profitable or available, like sardines and Pacific mackerel. In addition, the availability of jack mackerel can also be

Pacific Sardine U.S. Landings (t)

1992	19,000
1993	31,000

Northern Anchovy U.S. Landings (t)

1992	3,700
1993	4,500

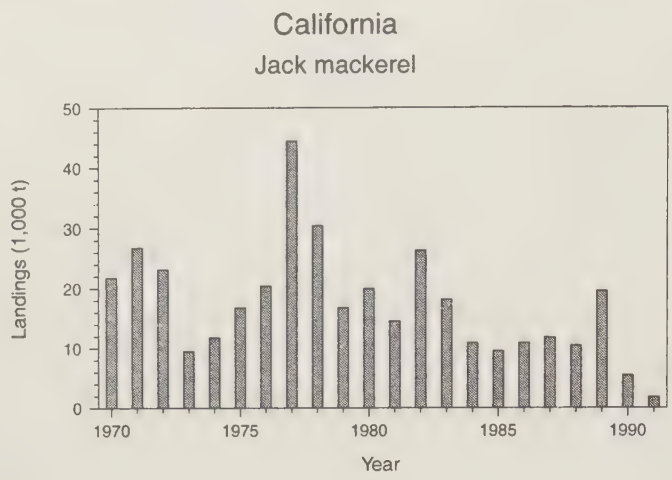


Fig. 14-4. Commercial landings of jack mackerel.

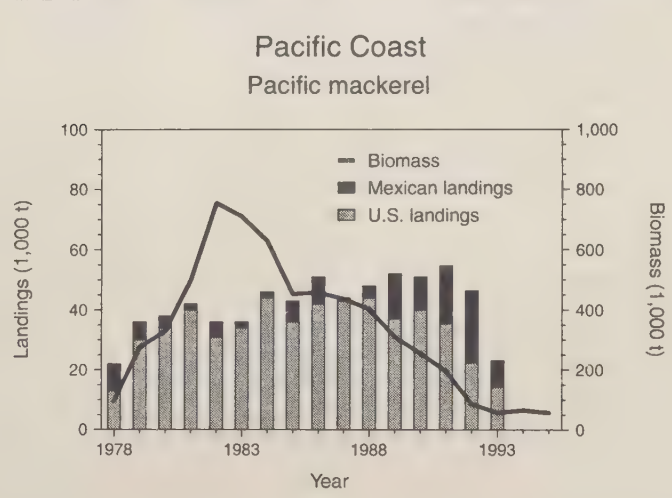


Fig. 14-5. Landings and biomass of Pacific (chub) mackerel.

Pacific Mackerel Landings (t)

1992	22,400
1993	14,300

California Pacific Herring Landings (t)

1993	3,900

very erratic. Jack mackerel has two distinct behavior patterns during its life cycle: juveniles are found inshore off southern California and Baja California while adult fish are distributed offshore and farther north, in some years, to as far as the Gulf of Alaska. Adult jack mackerel found offshore are sometimes caught incidentally by trawlers, particularly those targeting Pacific whiting.

The foreign trawl fisheries of the 1970s resulted in jack mackerel management being placed in the groundfish FMP and a bycatch quota of 12,000 t/year (north of lat. 39°N) was set. Restrictions on fishing for other groundfish species, including whiting, were thus avoided. The recent history of its commercial landings, mostly as incidental catch, is shown in Fig. 14-4. In 1991, interest in jack mackerel increased and the catch limit was raised to 52,000 t to allow a target fishery to operate. While this fishery has not yet materialized, signs of commercial interest continue. A purse seine fishery for jack mackerel has continued at a low level. Currently, it has no catch limit. Jack mackerel have been occasionally important to the partyboat sports fishery off southern California. It is also fished recreationally off piers.

Assessment and management of jack mackerel are difficult because of limited data and its broad distribution. The most recent estimate of biomass was made in 1983. Spawning biomass was estimated at 1.5 million t, and total biomass at 1.63-1.99 million t. Its potential yield is little more than an educated guess (Table 14-1).

Pacific (Chub) Mackerel

Pacific mackerel has a worldwide distribution in temperate and subtropical seas. On the Pacific coast, it is most abundant south of Point Conception, California. It supported one of California's major fisheries during the 1930-40s and again in the 1980s. It was second only to sardine during the heyday of the southern California sardine fisheries in the 1930-40s. The peak catch reached 73,000 t in 1935 and declined steadily thereafter. In 1970, a moratorium was placed on the fishery after the stock collapsed.

A series of successful year classes in the late 1970s initiated a recovery of the stock, and the fishery was reopened under a quota system in 1977. The resource is now harvested by three separate fisheries: the California commercial fishery, a sport fishery, and a Mexican commercial fishery. The recent history of U.S. harvest is shown in Fig. 14-5. From 1980 to 1989, the California recreational catch averaged 1,462 t per year.

The trend in chub mackerel biomass is also shown in Fig. 14-5. Recent peak abundance was 754,000 t in 1982. Abundance has declined to 87,000 t by 1992 and is thought to be continuing. Analyses of fish-scale deposits in ocean

bottom sediments off southern California indicate that the prolonged period of high mackerel biomass levels during the late-1970s and 1980s may have been unusual and would only be expected to occur, on average, about once every 60 years. In 1985, it was estimated that chub mackerel might sustain average yields between 26,000 and 29,000 t per year under management systems similar to that currently used to manage the stock by the State of California. The commercial catch is currently restricted by a quota of 10,800 t. If the biomass dips below 18,000 t, commercial fishing will be stopped.

Pacific Herring

Off the Pacific Coast, Pacific herring fisheries occur primarily off California. The fishery in Puget Sound, Washington, is small by comparison. The fishery off California has peaked three times during this century: during 1916-19 near 3,600 t, during 1947-53 near 4,500 t, and recently in 1982 near 10,000 t. In the earlier years, herring were harvested for reduction into fish meal and for pet food and bait. Some were canned to supplement the declining supply of sardines. Canned herring proved to be a poor substitute for sardines, and the fishery for human consumption ended in 1954.

Since 1973, herring in California have been harvested primarily for their roe for export to the Japanese market. Landings peaked in 1982 above 10,000 t (Fig. 14-6). Landings declined in 1984 when El Niño caused a corresponding decline in the herring population. However, most stocks have recovered somewhat and so have catches. The herring roe fishery is limited to California's four largest herring spawning areas: San Francisco Bay, Tomales-Bodega Bay area, Humboldt Bay, and Crescent City Harbor. San Francisco Bay has the largest spawning population of herring and supplies over 90 percent of the state's herring catch. The four spawning areas are managed separately by the California Department of Fish and Game, with catch quotas based on population estimates.

Another lucrative phase of the herring industry is the roe-on-kelp fishery. Beginning in 1965, scuba divers harvested species of marine vegetation with herring eggs attached from Tomales and San Francisco Bays. This product is exported as a Japanese delicacy. The fishery has evolved into the present roe-on-kelp fishery. Giant kelp is harvested from the Channel Islands off southern California, brought to San Francisco Bay, and suspended by 60 by 40 foot floating rafts. The rafts are towed to areas where herring spawning is expected to occur and are anchored. After spawning has ended, the kelp with herring eggs attached is removed from the rafts and packed in salt. Catches have been generally low (Fig. 14-7), but valuable.

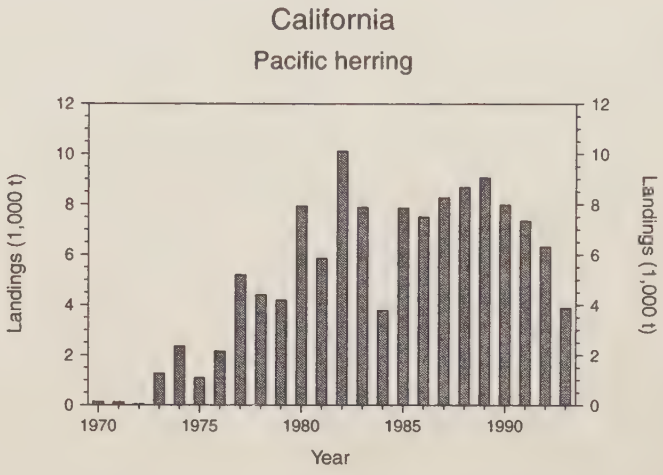


Fig. 14-6. Commercial landings of Pacific herring.

The herring spawning populations in Tomales and San Francisco Bays are estimated annually from hydroacoustic and spawning ground surveys. The spawning biomass has fluctuated widely in both areas since the 1983 El Niño through the more recent 1992-93 El Niño. The 1992-93 season estimates were a relatively high 3,700 tons in Tomales Bay and a relatively low 19,500 tons in San Francisco Bay. Humboldt Bay supports a smaller spawning stock, estimated in 1991 at 400 tons. Population estimates have not been made for the Crescent City herring stock, but observed spawning suggests that the population is large enough to support a minor fishery that occurs there.

Gulf of Alaska Pacific Herring Landings (t)

1993	21,300
1994	13,700

Bering Sea Pacific Herring Landings (t)

1993	25,900
1994	33,800

Alaska Pelagic Fisheries

Pacific Herring

Pacific herring is the major pelagic species that is harvested off Alaska. The fisheries occur

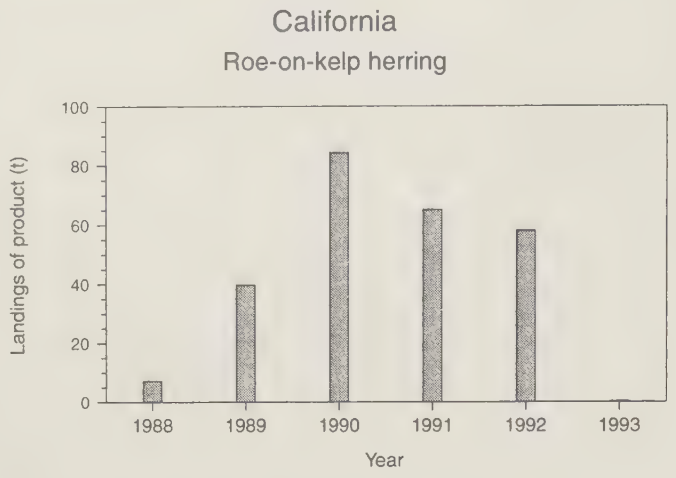


Fig.14-7. Recent landings of roe-on-kelp herring.

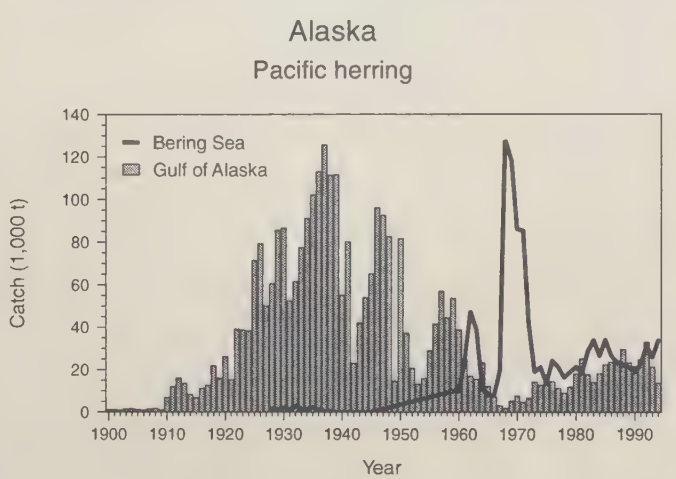


Fig. 14-8. Pacific herring landings.

in specific areas in the Gulf of Alaska and the Bering Sea when the stocks come inshore to spawn. In the Gulf of Alaska, spawning concentrations occur mainly off southeastern Alaska, in Prince William Sound, and around the Kodiak Island-Cook Inlet area. In the Bering Sea, the centers of abundance are in northern Bristol Bay and Norton Sound. The fisheries occur within state waters and are, therefore, managed by the State of Alaska. The ADF&G regulates and monitors the resource by 20 separate fisheries.

In 1994, the total herring harvest in Alaska was 47,480 t that fetched an ex-vessel value of $24 million. The majority of the harvest was roe-bearing herring (43,410 t) and the remainder was food-and-bait herring (4,070 t) and herring roe-on-kelp (180 t).

In the Bering Sea, catches peaked dramatically in 1970 at more than 120,000 t and fell off to 21,000 t in 1977 (Fig. 14-8). Since then catches have risen slowly but steadily, reflecting better stock conditions. A portion of the Bering Sea herring harvest is taken as bycatch in the groundfish fishery. Regulations now limit bycatch to about 1,000 t. The Gulf of Alaska herring fisheries have a long history of harvest going back to the 1900s. Catches peaked at over 120,000 t in 1936. In recent years, catches have risen steadily from its low level of abundance in 1967.

From catch records, it is evident that herring biomass fluctuates widely due to influences of strong and weak year-classes. The period since the mid-1970s seems to be one of low-to-moderate herring abundance. The Bering Sea stocks are at moderate levels, with fish mostly of moderately strong 1987 and 1988 year classes. In most of the Gulf of Alaska, herring stocks are at moderate abundance levels. A strong 1988 year class that is present in the stocks is now declining rapidly in abundance. This year class is being replaced by another strong year-class (the 1992 year-class) that should sustain abundance levels in the near future. In Prince William Sound, however, herring abundance is at a historical low following a disease outbreak in 1993.

Issues

Transboundary Stocks and Jurisdiction

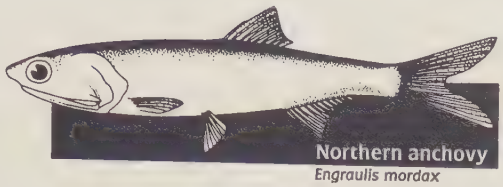
Mackerels, sardines, and anchovies are transboundary stocks exploited by both U.S. and Mexican fleets, but no bilateral management agreement has yet been reached for coordinated management of the stocks. Harvest levels are increasing in Mexican waters, and the absence of a governing bilateral agreement is compromising management of the same stocks that both countries fish on.

Underutilized Species

Jack mackerel is an underutilized species, while the Pacific sardine is increasing in abundance after decades at low levels. These species may support an increased harvest by U.S. fishermen in the near future.

Progress

NOAA biologists continue to work closely with Pacific coast state biologists and the Pacific FMC in assessing and managing the stocks. Stock assessment models have been developed for northern anchovy, Pacific sardine, and chub mackerel. The new models are more reliable and precise than earlier ones used to estimate biomass for these stocks. The models now utilize more data, including fish spotter data from pilots employed by commercial fishermen and CALCOFI ichthyoplankton data. ❑



Unit 15

Pacific Coast Groundfish Fisheries

Introduction

The groundfish fishery off Washington, Oregon and California is conducted across a diverse range of habitats and involves tens of species and several fishing gears. Domestic landings averaged about 30,000 t per year prior to the early-1970s. A foreign fishery began in the early-1960s for Pacific ocean perch and Pacific whiting. The long-lived Pacific ocean perch stock is still recovering from excessive foreign harvests that occurred during the 1960s, but the fishery for the more productive Pacific whiting stock evolved into a healthy joint venture, then wholly a domestic fishery, in 1991. By 1977, when work by the Pacific FMC on the Groundfish FMP was initiated, domestic landings of all groundfish had increased to 60,000 t and by 1982, when the FMP was implemented, landings peaked at 116,000 t. The recent average yield of non-whiting groundfish has returned to an average of about 70,000 t which appears to be sustainable for several of the species involved. However, many of the stock assessments do not have sufficient data to be precise, and substantial natural fluctuations occur in some species.

Several assemblages of fish contribute to the $81.6 million groundfish fishery in 1994 (Fig. 15-1). The midwater trawl fishery for Pacific whiting dominates the tonnage and whiting as a single species contributes the greatest value ($18.9 million ex-vessel value in 1994). A deepwater trawl fishery for sablefish, thornyheads, and Dover sole now operates out to near 1500 m. This trawl fishery and a longline and pot fishery for sablefish was worth $33.9 milion in 1994, with sablefish and thornyheads each contributing about 40% of this total. On the continental shelf and extending into the nearshore reef habitat is a trawl and hook & line fishery for tens of rockfish (*Sebastes*) species that was worth $20.2 million in 1994. Widow and yellowtail rockfish each contributed about 20% of this total value. An associated species is lingcod with landings worth $1.7 million in 1994. In addition, lingcod and some species of rockfish have substantial recreational harvests in some areas. Catch of nearshore flatfish was worth $6.1 million in 1994, with 40% coming from Petrale sole. Fishing and processing participants in the groundfish fishery also commonly participate in fisheries for shrimp, halibut, Dungeness crab, salmon, and albacore tuna. In 1993, the groundfish fishery contributed $70 million out of the total $191 million for these named fisheries.

Table 15-1. Pacific Coast Groundfish

Productivity in metric tons and status of fisheries resources

Species	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)[2]	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Pacific whiting[3]	189,765	223,000	336,000	Full	Below
Sablefish	8,298	9,100	9,800	Full	Near
Ling cod	1,985	2,400	3,100	Over	Below
Pacific cod	1,336	3,200	Unknown	Under	Unknown
Flatfishes					
Arrowtooth flounder	3,173	5,800	Unknown	Under	Unknown
Dover sole	13,170	15,000	16,300	Full	Below
English sole	1,424	3,100	3,100	Under	Above
Petrale sole	1,445	2,700	2,700	Full	Near
Other flatfish	2,058	7,700	Unknown	Unknown	Unknown
Rockfishes					
Bocaccio	1,401	1,700	1,800	Full	Below
Canary rockfish	1,926	1,250	1,250	Over	Below
Chilipepper rockfish	1,362	4,000	4,000	Under	Above
Pacific ocean perch	1,101	Unknown	1,100	Over	Below
Shortbelly rockfish	37	23,500	23,500	Under	Above
Thornyheads	8,482	8,000	6,600	Full	Near
Yellowtail rockfish	5,177	6,740	6,700	Full	Above
Widow rockfish	6,629	7,700	6,700	Full	Near
Other rockfish[4]	9,110	11,500	Unknown	Full	Unknown
Other fish	4,578	14,700	Unknown	Unknown	Unknown
Total	262,457	352,191	465,550		

[1] RAY is the average 1992-94 landed U.S. commercial catch.
[2] CPY is taken from the Pacific FMC's Acceptable Biological Catch for 1995.
[3] Pacific whiting RAY for U.S. + Canada was 284,694 t, including discards. Pacific whiting CPY and LTPY are for combined nations. Prorated U.S. portion of Pacific whiting CPY = 178,400 t and LTPY = 268,800 t.
[4] Significant recreational catches include 1,080 t lingcod, 200 t bocaccio, and 5,000 t of other rockfish including 600 t of black rockfish in Oregon and Washington.

Management Situation

Recommendations for management of the Pacific coast groundfish fisheries are developed

by the Pacific FMC. The Groundfish FMP calls for establishment of an annual ABC and Harvest Guideline (HG) for major groundfish species. Although brief, "derby" fisheries of a few weeks duration have been used for a portion of the whiting and fixed gear sablefish harvests, most elements of the fishery have a goal of year-round fishing opportunity. Achievement of a year-round fishing opportunity in the face of excessive fishing effort has been achieved by imposition of limits on individual vessels. These limits have evolved from per trip limits for widow rockfish beginning in 1983, to monthly cumulative limits for each vessel for each of several species today. Inseason adjustment of these limits has been mostly successful in keeping the annual harvest close to the HG while allowing year-round fishing opportunities. However, some abrupt changes to the limits have been disruptive to the industry, and the restrictive nature of these limits causes discard of excessive catch. The expected level of discard (8-20%) is taken into account when setting the annual HG below the ABC. Development of observer programs to estimate the amount of discard, biological studies to determine the mortality rate of discarded fish, and study of co-occurrence patterns among species are needed.

In 1994 a limited entry (LE) program was implemented for the groundfish fishery. The transferable LE permits have endorsements for vessel size and primary gear in order to maintain the existing fleet composition. A formula for combining permits from smaller vessels into a single permit for a larger vessel has allowed several large (>200 ft.) catcher-processors to buy permits and participate in the Pacific whiting fishery. Implementation of the LE system has been beneficial in creating a well-defined set of participants, but it has not decreased the number of participants sufficiently to allow for increases in the monthly vessel limits. Non-permitted vessels may participate in a small-scale, open access fishery.

Other major restrictions on the groundfish fishery include a minimum mesh size on trawls to allow escapement of undersized fish, and area/season restrictions on the whiting fishery to decrease bycatch of salmon.

Species and Status

The Pacific coast groundfish fisheries are generally managed with a constant proportional rate of harvest such that the expected level of egg production (or spawning biomass) per recruit will be 35% of the unfished level. The exception is Pacific whiting which has a more conservative and varying harvest rate in recognition of the extreme natural fluctuations in recruitment. Because many groundfish species have longevity in the 40-100 year range, the annual exploitation rates that achieve the spawning biomass per recruit goal are often as low as 5-10%. Thus, it has taken many years for these low exploitation rates to reduce the stock abundance from the lightly exploited levels of the 1960s to the fully exploited levels of today. Reductions in recommended annual harvest amounts over the past decade for sablefish, widow rockfish and some other species has been a direct result of this "fishing down" of the surplus biomass. In no case has the fishing down been smoothly along a constant rate of exploitation. Rather, imprecise stock assessments, insufficient staff to revise assessments frequently, and natural fluctuations in abundance contribute to changes in recommended harvest levels.

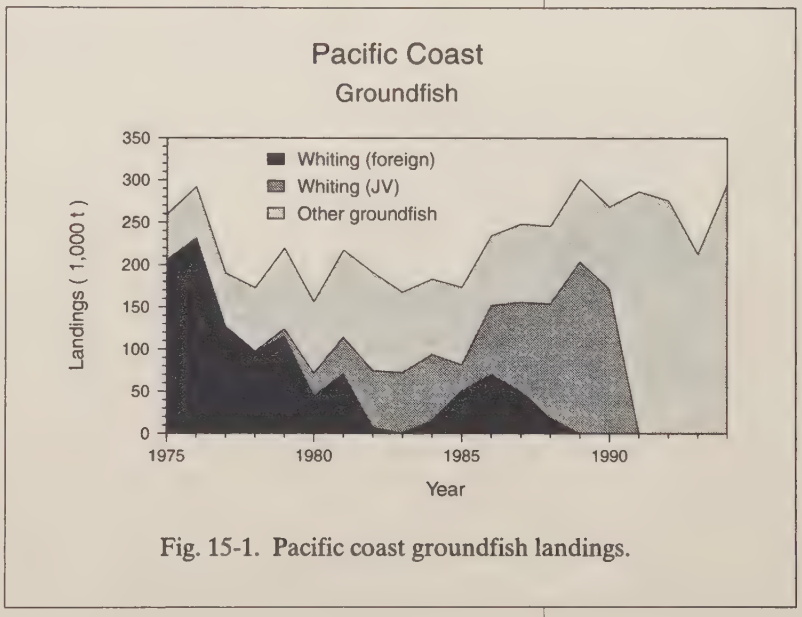


Fig. 15-1. Pacific coast groundfish landings.

Pacific Whiting Landings (t)	
1993	141,200
1994	252,700

The groundfish stocks are generally fully utilized (Table 15-1), although a few species such as shortbelly rockfish and jack mackerel remain essentially unutilized because of lack of market. Pacific whiting is fully utilized, but its abundance has been on a decline because of lack of strong recruitment since the 1984 yearclass.

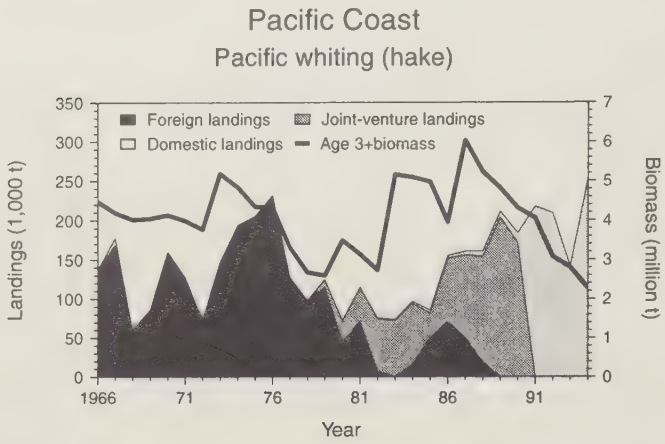


Fig. 15-2. Pacific whiting landings and biomass (ages 2 and older).

Pacific Coast Other Groundfish Landings (t)

1993	71,400
1994	62,000

The four species in the deepwater fishery are near full utilization. Within this set, sablefish abundance and RAY appear near long-term potential levels, Dover sole abundance appears to have declined below target levels because of low recruitment in southern areas and because of high exploitation during the mid-1980s off Oregon. The abundance of shortspine thornyheads appears to be below its target level, and the deeper living, smaller bodied longspine thornyhead has not yet been fished down to its target level. However, the assessments for all four of these species have considerable uncertainty, and the sablefish assessment has been subject to a high level of scrutiny and criticism from the fishing industry.

Within the set of rockfish, widow rockfish is relatively stable near its target level of abundance and yield. Off California, chilipepper rockfish have had a large recent increase in recruitment, while bocaccio continue to decline with reduced recruitment since the 1977 yearclass. Off Oregon and Washington, canary rockfish has declined substantially in recent years due partly to overharvest resulting from imprecise stock assessment information. A reduced harvest guideline and new vessel limits were established for canary rockfish in 1995. In that same area, yellowtail rockfish appears healthy and at a high level of abundance due to recent high recruitment. Pacific ocean perch appears to be only slowly rebounding from overharvest that occurred in the 1960s. The current level of catch, intended as bycatch in other groundfish fisheries, is near the overfishing level of exploitation. Black rockfish, an important recreational species off Oregon and Washington, appears fully utilized and probably is near its target level of abundance. However, the precision of all these rockfish assessments appears low given the amount of available information. For other species of rockfish, no estimates of abundance and exploitation rates are available.

A first time assessment for lingcod in the northern area indicates that harvest over the past decade has bordered on overfishing; so in 1995 reduced harvest guidelines and new vessel limits were imposed.

Among the other flatfish species, English sole appears to be at a high level of abundance due to large recent recruitments, and Petrale sole is near its target level of abundance and yield.

Recreational Fisheries

The non-salmon recreational fishery harvests a diverse collection of nearshore fishes, including many species of groundfish managed by the Pacific FMC. Coastwide sampling of the recreational fishery resumed in 1993 after a three year break. Analysis of recreational fishery data from 1993 and 1994 is underway at this time, and more complete reporting will be included in future volumes of this report. Valuation of the recreational fishery for groundfish is important, but more difficult than estimating the magnitude of the catch. In some cases, proxy values from the recreational fishery for salmon have been used in estimating the economic impact of changing regulations for the recreational groundfish fishery.

Among the groundfish species, the recreational component is particularly important for lingcod and some species of rockfish. Off California, the catch of lingcod by recreational fishermen is approximately equal to that of the commercial fishery. In 1993, the recreational catch of rockfish off California was 4.7 million fish. This may represent approximately 5,000 t, so is of comparable magnitude to the 7,000 t of rockfish (excluding thornyheads and widow rockfish) harvested by the commercial fishery in California in 1993.

Off Washington and Oregon, the charter boat fishery has relied on black rockfish to offset declining opportunities to fish for salmon. In

recent years, the recreational catch of black rockfish has been about 300 t in each of these states. Commercial catch of black rockfish has been less than half of this level. The Pacific FMC has supported initiatives to provide long-term protection for this recreational fishing opportunity by recommending spatial segregation between recreational and commercial fisheries for black rockfish, and by imposing restrictive trip limits and bag limits on the commercial and recreational fisheries, respectively.

Landings

The landed catch of most species is well-monitored through a system of State fish landing receipts and collation of computerized copies of these receipts into the centralized Pacific Fisheries Information Network (PacFIN) database. Unfortunately, funding for biological sampling of the landings is inadequate, so the species composition of mixed rockfish landings is not well known, and size and age composition data are not adequate for many species.

The combined nation (Canada-U.S.) harvest of Pacific whiting reached a record level of 358,900 t in 1994 (of which 252,700 t were caught in the U.S., Fig. 15-2). The increase in 1994 was due to a new stock assessment based on an expanded and improved survey. However, the stock's abundance continues to decline due to recent reduced recruitment, and current projections for available total yield in 1996 are below the 114,000 t average level that occurred during 1978-83.

The landed catch of non-whiting groundfish averaged 85,000 t per year during 1985-1990, then declined to about 62,000 t in 1994 as several major stocks were completing the process of being fished down to long-term target levels of abundance (Fig. 15-1). Nearly 10,000 t of this decline in annual yield is due to Dover sole, with much of the remainder contributed by sablefish (Fig. 15-3) and widow rockfish. Table 15-1 documents the recent average yield.

Issues and Progress

Balancing Between Competing Users

Management of the Pacific coast groundfish fisheries involves old and new allocation issues. The Pacific whiting available yield is allocated first between the U.S. and Canada, and then between shoreside and at-sea deliveries within the U.S. The U.S. and Canada have not come to full agreement on the allocation, with the U.S. now setting its harvest guideline at 80% of the overall ABC, and Canada setting its harvest guideline such that it will be 30% of the combined harvest guidelines. This overharvest may have contributed to the stock's decline in recent years. The sablefish harvest guideline is allocated between a Native American fishery, an open access fishery, limited entry trawl, and limited entry fixed gear. The allocation between limited entry and open access is by a fixed percentage for each species as established in the FMP, but the level of allocation to open access has the potential to become more contentious for lingcod and some rockfish. Direct allocation between recreational and commercial fisheries has not occurred, however recent actions on black rockfish have been designed to preserve recreational fishing opportunities for this species.

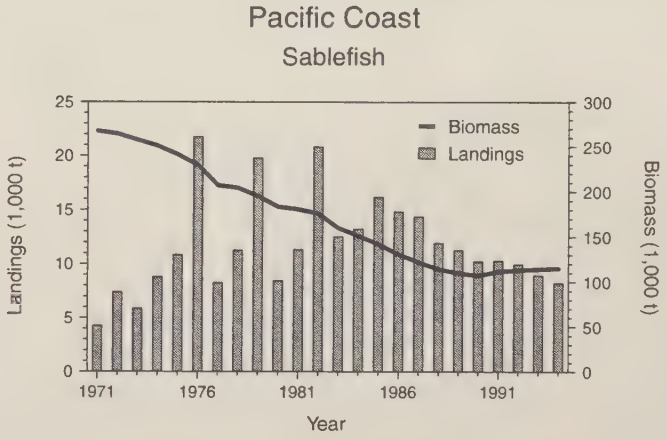


Fig. 15-3. Total landings and biomass (ages 3 and older) of sablefish.

Indirect allocation between high capacity and low capacity participants affects many management issues. For whiting, the direct allocation between a brief at-sea fishery and a protracted fishery for shoreside deliveries is partly a consequence of this issue. For fixed gear sablefish, the debate in recent years has been between a ever-shortening derby fishery, movement to an ITQ fishery (which could favor high capacity participants), or movement to a protracted trip-limit fishery (which could favor low capacity participants). For trawlers, the

decline in trip limits over the past decade has had the greatest impact on the vessels that already invested in advanced harvesting capability, yet did not greatly deter other vessels from increasing their capability.

Bycatch considerations have not much entered into allocation arguments, partly because the lack of a comprehensive at-sea observer program has hindered collection of data on the magnitude of bycatch. For example, past arguments on trawl/fixed gear allocation of sablefish hinged on unanswerable questions regarding whether sablefish was a target fishery for trawlers, or unavoidable bycatch as they targeted other species. More recently, an estimate of Pacific halibut bycatch in the groundfish trawl fishery has increased the potential for this to become a new allocation issue. Both of these issues need better estimates of the amount of discard, and the survival rate of discarded fish.

Merluccius productus

Ecosystem Considerations

Accurate, long-term predictions of potential yield will require a substantial increase in our knowledge about competitive and predatory interactions in the biological system that includes Pacific coast groundfish, and about climate effects on this community. The target exploitation rate for most groundfish species is designed to achieve a large fraction of maximum potential yield, while reducing the abundance of spawners by about 2/3, yet not much reducing the mean recruitment level. Only decades of monitoring the stock's performance will ascertain the long-term feasibility of these targets, and the degree of natural fluctuation that will occur while maintaining these targets. Unfortunately, there is little historical data, and the current level of stock assessment data is not adequate to precisely track changes in abundance for more than a few species. In addition, only a low level of effort is directed towards food habits studies that may help predict how the interactions among species may change as the abundance of several major species is reduced below unfished levels.

Models of long-term potential yield depend on assumptions of constant average environmental conditions or an ability to predict changing conditions. There is evidence of a decline in zooplankton abundance within the 40 year time CalCOFI time series, and evidence of an ocean warming during the late-1970s. Dover sole in southern areas and bocaccio rockfish exhibit declines in mean recruitment during this same period. Better understanding of potential linkages between fish recruitment and long-term changes in the ocean climate are key to improved 5-10 year forecasts of fishery potential yield. ❑

Western Pacific Invertebrate Fisheries

Introduction

Important invertebrate fisheries in the Western Pacific include spiny and slipper lobsters and the gold, bamboo, and pink corals. The fisheries are relatively recent and range from the Hawaiian Islands EEZ to Guam, America Samoa, and various U.S. Pacific Islands.

The Northwestern Hawaiian Islands (NWHI) lobster fishery began in 1977, and an FMP was implemented in 1983. The FMP defines a minimum legal size for harvested lobsters, requires the use of escape vents on traps, forbids the retention of ovigerous females, and requires vessel operators to submit logbooks of daily catch and fishing effort.

The NWHI are uninhabited, and there is no recreational fishery—all harvests are commercial. Commercial lobster vessels carry about 800-1,000 traps which are used on 1-2 month fishing trips. The fishery targets spiny lobsters, which are marketed mostly as frozen tails. The fishery is managed by the Western Pacific FMC.

A short lived (1974-79) fishery for several gold, bamboo and pink corals existed off Makapu'u Point, Oahu, Hawaii. Since then, the prohibitive cost of fishing such difficult-to-harvest deep-water corals has stifled U.S. exploitation. With the exception of one aborted attempt at Hancock Seamount in the Hawaiian EEZ in 1988, legal domestic harvesting of precious corals within the EEZ has been non-existent for 14 years. There are no recreational coral fisheries. Precious corals within the EEZ are managed under the Precious Coral FMP, implemented in 1983 by the Western Pacific FMC.

Species and Status

Lobster

Spiny and slipper lobsters are fished in the western Pacific, primarily in the NWHI area. The NWHI lobster landings and CPUE peaked in the mid-1980s, then gradually declined during the years 1985 through 1990 (Fig. 16-1). The substantial decrease in both landings and CPUE after 1989 raised concerns that fishing effort was excessive for the existing lobster population. Low lobster CPUE continued into the early part of 1991, prompting an emergency closure of the fishery from May through November of 1991. In response to the substantial decline in CPUE, the FMP was amended in 1992 to limit entry into the fishery, establish an annual 6-month (January-June) closed season to protect spawning biomass, and set an annual catch quota. The quota is set at a level that provides harvesters an economically viable CPUE while protecting spawning biomass from over-harvest. The quota allows surplus production to be harvested if the population size (in terms of CPUE) is sufficiently large. The 1993 preseason forecast of lobster abundance indicated that the

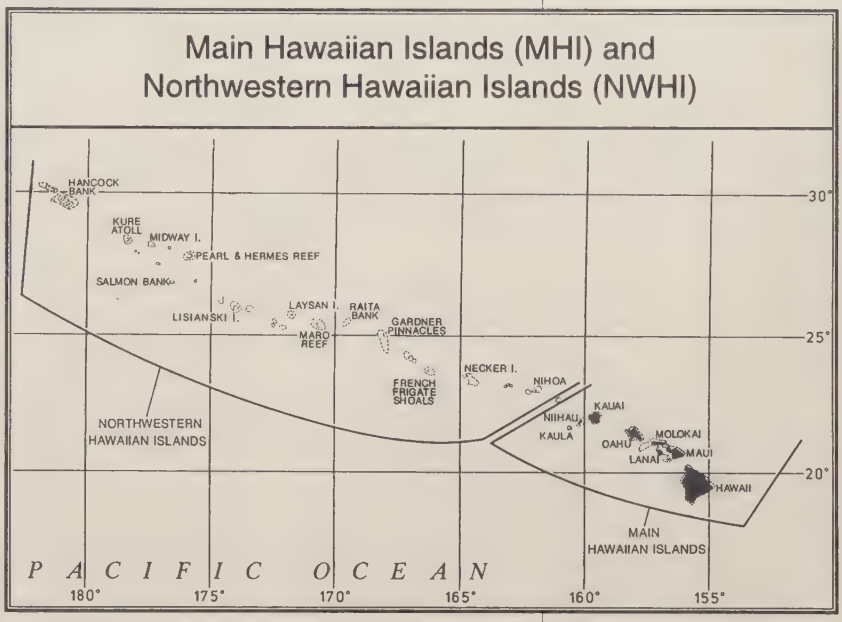


Table 16-1. Western Pacific Invertebrates

Productivity in metric tons and status of fisheries resources

Species	Recent Average Yield (RAY)	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Spiny and Slipper Lobster	143	106	135	Over	Below
Total	143	106	135		

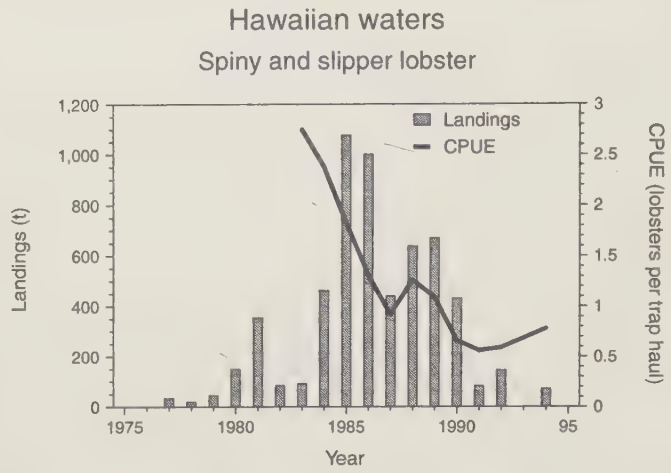


Fig. 16-1. Spiny and slipper lobster landings and CPUE.

Hawaiian Spiny & Slipper Lobster Landings (t)	
1992	144
1994	72

lobster stock was too small to support a viable commercial fishery in 1993, so the fishery was closed. In 1994, the preseason forecast of lobster abundance indicated the population was rebuilding sufficiently to allow a fishery in 1994. The fishery was therefore opened July 1, 1994, but was closed in mid-August because CPUE monitoring during July and early August indicated that the population was smaller than predicted.

Recent research suggests that the decline in CPUE after 1989 was caused by changes in meso-scale oceanographic processes in the NWHI that reduced annual lobster recruitment, and that recruitment may remain at this lower level for several years. CPUE data from the commercial fishery indicate a general rebuilding trend in the stock since 1991 (Fig. 16-1); the stock is recovering to levels that will produce the economically optimum CPUE as defined under the FMP. The stock size is slightly below the level that would produce LTPY under the current level of recruitment (Table 16-1).

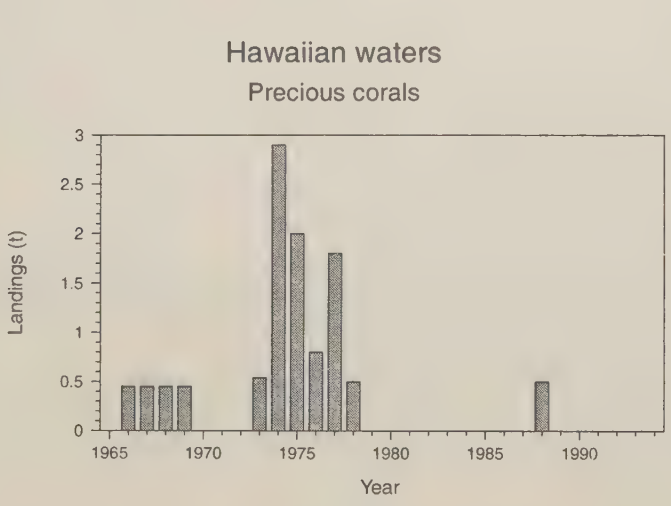


Fig. 16-2. Landings of precious corals.

Coral

Fishing for coral is by regular or "experimental" fishing permit only. The FMP regulates precious coral fisheries within the EEZ management unit seaward of the MHI and NWHI, Guam, American Samoa, and the U.S. Pacific island possessions of Johnston Atoll, Kingman Reef, and Palmyra, Wake, Jarvis, Howland, and Baker Islands. Historical landings of precious corals are shown in Fig. 16-2.

Issues and Progress

Recent research suggests that ecosystem productivity in the NWHI is correlated with meso-scale oceanographic processes which may fluctuate on a decadal scale. The reduced level of lobster recruitment since 1989 is consistent with observed declines in seabird, monk seal, and reef fish populations in the NWHI. If the recent reduction of lobster spawning biomass is primarily due to changes in productivity and lobster recruitment, lobster LTPY is now lower than the LTPY level of the 1983-1989 period.

The lobster population model used to monitor population changes, forecast abundance and set harvest quotas involves critical assumptions about recruitment. To improve the accuracy of forecasts, the Honolulu Laboratory is studying the relationships among juvenile abundance, adult abundance, and recruitment. Research objectives include finding ways to monitor recruitment and detect changes in recruitment due to environmental shifts and other factors. Studies are also planned to determine the mortality of sub-legal sized lobsters discarded by the fishery, and to develop an improved quota procedure that provides greater year-to-year quota stability and dependability while minimizing the risk of overfishing. ❑

Western Pacific Bottomfish and Armorhead Fisheries

Introduction

The bottomfish fishery geographically encompasses the Main Hawaiian Islands (MHI), the Northwestern Hawaiian Islands (NWHI), the Territory of Guam, the Commonwealth of the Northern Mariana Islands (CNMI), and the Territory of American Samoa (Table 17-1). In contrast, the pelagic armorhead is harvested from the summits and upper slopes of a series of submerged seamounts along the southern Emperor-northern Hawaiian Ridge. This chain of seamounts is located just west of the international dateline and extends to the northernmost portion of the NWHI.

The Guam, CNMI, Samoa, and MHI fisheries employ relatively small vessels on 1-day trips close to port; much of the catch is taken by either part-time or sport fishermen. In contrast, NWHI species are fished by full-time fishermen in relatively large vessels that range far from port on trips of up to 10 days. Fishermen use the handlining technique in which a single weighted line with several baited hooks is raised and lowered with a powered reel. The bottomfish fisheries are managed jointly by the Western Pacific FMC and territorial, commonwealth, and state authorities.

The seamount fishery for armorhead was initiated by bottom trawl vessels of the former Soviet Union in 1968. During the next year, Japanese trawlers entered this fishery and by 1972 CPUE (based on Japanese data) peaked at some 54 t/hour (Fig. 17-1). From the inception of this fishery to the present, the U.S. has never been a participant in the seamount trawl fishery for armorhead. By the end of 1975, the two fleets had harvested a combined cumulative total of some 1 million mt of armorhead. With the steady decline in CPUE after 1972, the former Soviet fleet left the fishery after 1975. The combined CPUE for all seamounts has remained depressed since the late-1970s. The inclusion in 1977 of the southernmost seamounts (Hancock Seamounts) into the U.S. EEZ allowed for a small portion of the fishery to be managed in a limited way. A Preliminary Management Plan was developed that year which provided for limited foreign harvesting at the Hancock Seamounts under a permit system during 1978-1984. However, catches remained low, all fishing ceased after 1984, and under the bottomfish and seamount groundfish FMP, a 6-year fishing moratorium was imposed on the Hancock Seamounts in 1986. The moratorium was extended for an additional 6-year period in 1992.

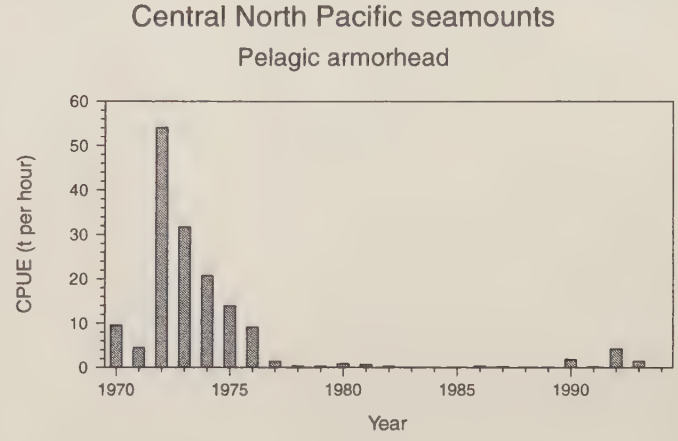


Fig. 17-1. Catch per unit effort of pelagic armorhead taken by Japanese trawl fishery.

Table 17-1. Western Pacific Bottomfish and Armorhead

Productivity in metric tons and status of fisheries resources

Species / Area	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Bottomfish					
MHI	211	211	200	Over	Below
NWHI	139	335	335	Under	Near
America Samoa	7	31	31	Under	Near
Guam	27	25	25	Over	Below
CNMI	4	24	24	Under	Near
Pelagic armorhead	0	0	2,123	Over	Below
Total	388	626	2,738		

[1] 1992-94 average for NHI and NWHI; 1991-93 average for American Samoa, Guam, and CNMI.

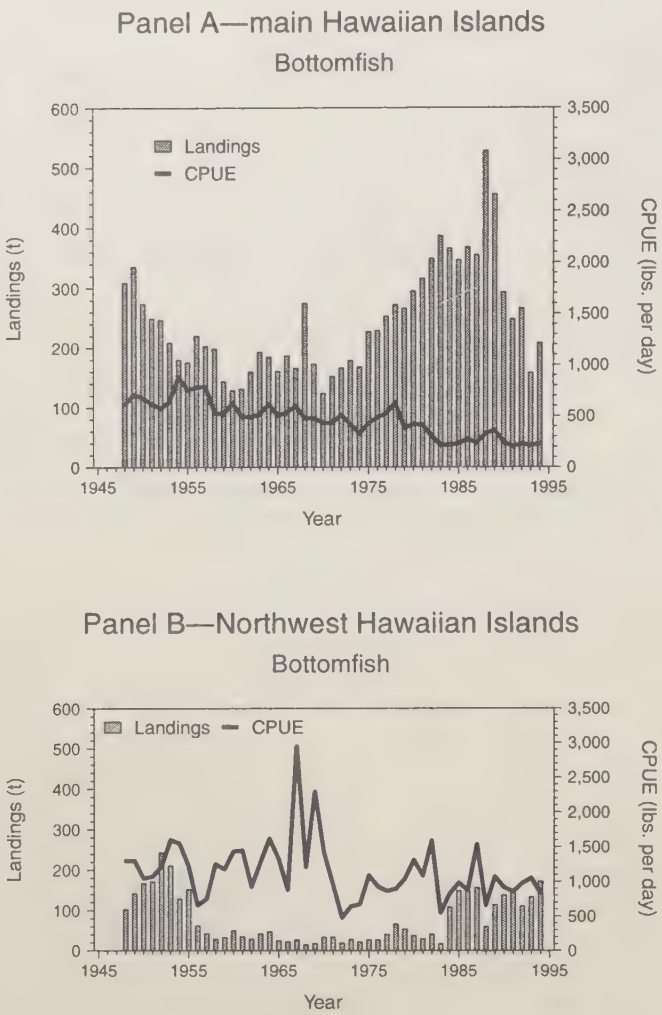


Fig. 17-2. Bottomfish landings and CPUE at Main Hawaiian Islands (Panel A) and at NW Hawaiian Islands (Panel B).

MHI Bottomfish Landings (t)

1993	158
1994	208

NWHI Bottomfish Landings (t)

1993	133
1994	172

Species and Status

Bottomfish

In Hawaii, the bottomfish species fished include several snappers (ehu, onaga, opakapaka), jacks (ulua, butaguchi), and a grouper (hapu'upu'u), whereas in the more tropical waters of Guam, CNMI, and Samoa the fishes include a more diverse assortment of species within the same families as well as several species of emperors. These species are found on rock and coral bottoms at depths of 50-400 m. Catch weight, size, and fishing effort data are collected for each species in the five areas. However, the sampling programs vary in scope between the areas. About 90% of the total catch is taken in Hawaii, with the majority of the catch taken in the MHI as compared to the NWHI (Fig. 17-2).

Stock assessments, though somewhat limited, indicate that the spawning stocks of several important MHI species (ehu, hapu'upu'u, onaga, opakapaka, and uku) are at only 10-30% of original levels. Onaga presently appears to be the most stressed among MHI bottomfish species.

Pelagic Armorhead

The seamount groundfish fishery targets just one species: the pelagic armorhead. Since 1976, this bottom trawl fishery has been almost exclusively conducted by Japanese trawlers fishing the seamounts located in international waters beyond the Hancock Seamounts. The fishing grounds comprising the Hancock Seamounts represent less than 5% of the total fishing grounds. The long-term potential yield (Table 17-1) is 2,123 t, but recovery to these former levels has not occurred.

Standardized stock assessments were conducted during 1985-1993. Research cruises were focused on Southeast Hancock Seamount and the armorhead stock was sampled with bottom longlines, calibrated against Japanese trawling effort. Catch rates vary but have not shown the increases expected after the fishing moratorium was implemented (Fig. 17-3). Furthermore, the increase in the 1992 seamount-wide CPUE (Fig. 17-1) due to high recruitment was apparently short-lived as CPUE declined appreciably in 1993. Closure of only the small U.S. EEZ portion of the armorhead's demersal habitat may not be sufficient to allow population recovery, because these seamounts remain the only portion of the fishery currently under management.

Issues

Scientific Advice and Adequacy of Assessments

Adequacy of the biological and catch data collected is a primary management concern for the Western Pacific bottomfish fishery. For example, the reproductive biology of many of

the important species in Guam, CNMI, and Samoa is unknown, and spawning stock biomass cannot be computed.

Transboundary Stocks and Jurisdictions

The primary issue for the armorhead seamount fishery is how to implement some form of management on an international basis which would provide conditions more conducive for stock recovery. The recruitment event of 1992 and subsequent stock decline (probably from over-harvesting) reiterate the need to implement some form of management if this fishery is to recover to early-1970s levels.

Management Concerns

The spawning stocks of several important MHI bottomfish species (ehu, hapu'upu'u, onaga, opakapaka, and uku) appear to be at about 10-30% of original levels. Thus, overutilization is a concern, and the Western Pacific FMC has recommended that the State of Hawaii take action to prevent overfishing because the fishery and the bottomfish habitat are predominantly within state waters.

Progress

Researchers continue to identify nursery habitat for juvenile snappers and groupers in Hawaii, and age and growth curves have been extended to include early juvenile stages. Improvements have been implemented for collection of more complete catch-and-effort data from the NWHI fishery. Fishery discard patterns and interactions with sharks and protected species have also been examined in the NWHI fishery.

No progress toward cooperative international management is foreseen for pelagic armorhead. Cooperative exchanges of fishery data with scientific colleagues in Japan have provided annual commercial catch data by seamount. Recently acquired biological data of importance for future management considerations indicate that armorhead undergo a two-year pelagic phase prior to recruitment into the fishery and that the seamount populations comprise a single stock. ❑

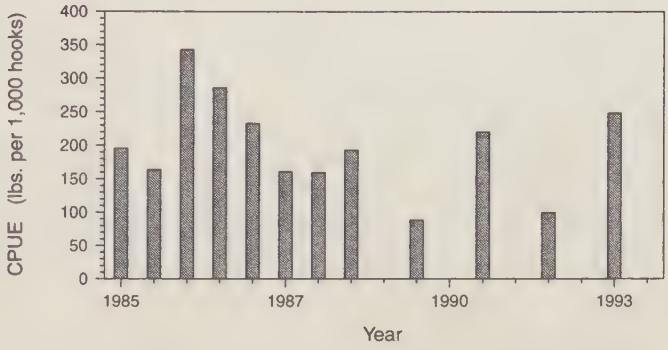


Fig. 17-3. Pelagic armorhead CPUE from bottom longlines of research cruises.

Unit 18

Pacific Highly Migratory Pelagic Fisheries

Introduction

The fishes in this group range the high seas and often are outside U.S. fisheries management jurisdiction. The status of many are either uncertain or unknown. Some species are sought vigorously by both commercial and sport fishermen.

During 1976-80, the eastern tropical Pacific (ETP) tuna fishery expanded and was dominated by the United States. Fishing became less profitable in the 1980s, and many U.S. fishermen quit or moved to the central-western Pacific (CWP), leaving Mexico, with over 50 purse seiners, the dominant fleet in the ETP. In the next decade, U.S. vessels decreased to about 7 in 1993-94 in response to dolphin mortality concerns. Purse seiners (all countries) in the ETP in 1993 numbered over 148. Currently, there is no international tuna management in the ETP; each coastal nation regulates fishing within its own EEZ. Until 1980 the Inter-American Tropical Tuna Commission (IATTC) regulated the international fishery with catch quotas. Since then, IATTC regulations have been suspended because Mexico is not a Commission member.

Also, there is no overall resource management program in the CWP, though the Forum Fisheries Agency (FFA), which represents the concerned South Pacific island nations, has instituted a licensing program for foreign (distant-water) fishing fleets through access agreements. The U.S. fleet is currently limited to 55 purse seiners in the FFA region under an access agreement (South Pacific Regional Tuna Treaty).

Presently, there are no management regimes for the North or South Pacific albacore fisheries. In the South Pacific, multilateral discussions between Pacific island nations and distant-water fishing nations, including the United States, were held to explore various management schemes. Following the demise of drift gillnet fishing in the South Pacific, these negotiations were suspended in 1992 due to lack of further interest.

U.S. billfish harvests (except for swordfish) have been dwarfed by foreign harvests (mostly from longline and drift gillnet fisheries). There is no international authority managing these species in the Pacific. U.S. management authority for billfish and tuna rests with the Western Pacific FMC for central and western Pacific waters, and with the Pacific FMC for North American waters (although the latter has delegated management to the State of California for swordfish, striped marlin, and some sharks). The temperate water bluefin tuna is not considered here, as most catches have been relatively minor off California in recent years. This species is taken incidentally while purse seine fishing for other species (anchovy and mackerel; yellowfin and skipjack tuna).

Species and Status

"Highly migratory" pelagic species include tropical tunas (yellowfin, bigeye, and skipjack), albacore, marlins, sailfish, swordfish, sharks,

Table 18-1. Pacific Highly Migratory Pelagics

Productivity in metric tons and status of fisheries resources

Species / Area	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Yellowfin tuna (CWP)[2]	369,233	Unknown	Unknown	Unknown	Near
Yellowfin tuna (ETP)[3]	332,033	250,000	Unknown	Full	Near
Skipjack tuna (CWP)	959,000	Unknown	Unknown	Under	Near
Skipjack tuna (ETP)	73,000	Unknown	Unknown	Under	Near
Albacore (North Pacific)	46,800	Unknown	80,000	Over	Below
Albacore (South Pacific)	30,833	Unknown	Unknown	Unknown	Near
Bigeye tuna	152,011	160,000	160,000	Full	Near
Blue marlin	22,057	Unknown	Unknown	Over	Below
Black marlin	4,230	Unknown	Unknown	Unknown	Near
Striped marlin	11,746	Unknown	Unknown	Under	Near
Sailfish and shortbill spearfish	5,729	Unknown	Unknown	Unknown	Near
Swordfish	29,125	Unknown	25,000	Under	Near
Wahoo	527	Unknown	Unknown	Unknown	Near
Dolphinfish (mahi mahi)	30,614	Unknown	Unknown	Unknown	Near
Pelagic sharks	10,294	Unknown	Unknown	Unknown	Unknown
Total	2,077,232	2,003,188	2,033,706		
U.S. Subtotal	240,438	248,427	278,945		

[1] 1990-92 average; includes U.S. and foreign landings; U.S. landings were 240,483 t of tunas, swordfish, and billfish only.
[2] CWP = central-western Pacific Ocean.
[3] ETP = eastern tropical Pacific Ocean.

and other large pelagic fishes. Most are caught commercially, but some, especially marlins, support important recreational fisheries as well.

Tropical Tunas

Longline gear is used to catch yellowfin and bigeye tunas across the Pacific, whereas the purse seine is the primary gear in the ETP and the western Pacific for capture of yellowfin and skipjack tunas. Purse seine fishing is conducted generally between lat. 20°N and 20°S. Longline fishing extends to higher latitudes (e.g., to 40°N). Other gears used in the CWP fisheries include ring net, handline, and pole-and-line. Purse seiners, dominated by U.S. and Japanese fleets but currently challenged by Korean and Taiwanese fleets, take 30-50% of the yellowfin tuna catch in the CWP. In 1993, the total number of purse seiners in the CWP was more than 200, including 42 U.S. seiners. Virtually all skipjack tuna is taken by pole-and-line and purse seine. Most of the bigeye tuna catch is taken by longline gear.

Mexico is the primary fishing nation in the ETP. Others include the United States, Vanuatu, Venezuela, and some other coastal nations. Major fishing nations in the CWP are the United States, Japan, the Republic of Korea, and Taiwan. Current, recent, and long-term potential yields for the various species are given in Table 18-1.

More skipjack tuna are caught than any other tuna species. The RAY of Pacific skipjack tuna by U.S. and foreign fleets is 959,000 t from the CWP and 73,000 t from the ETP (Fig 18-1); recreational catches are small. The species is believed underutilized, though the LTPY is unknown. The annual dockside ex-vessel revenue of the U.S. and foreign Pacific skipjack tuna catch is about $825 million, and for yellowfin tuna it is well in excess of $561 million. These figures are based on a conservative dockside price of $800/t for both species. The RAY of yellowfin tuna for the entire Pacific is about 701,000 t (Table 18-1), distributed about equally between the ETP and the CWP (Fig. 18-2). Recent assessments of yellowfin tuna indicate that the LTPY for the ETP is about 250,000 t, making this resource fully utilized. The LTPY for the CWP is unknown because a comprehensive analysis of potential yield has not been performed. However, catch rates are fairly steady, and preliminary analyses of stock condition suggest that the fishery may be nearing full production.

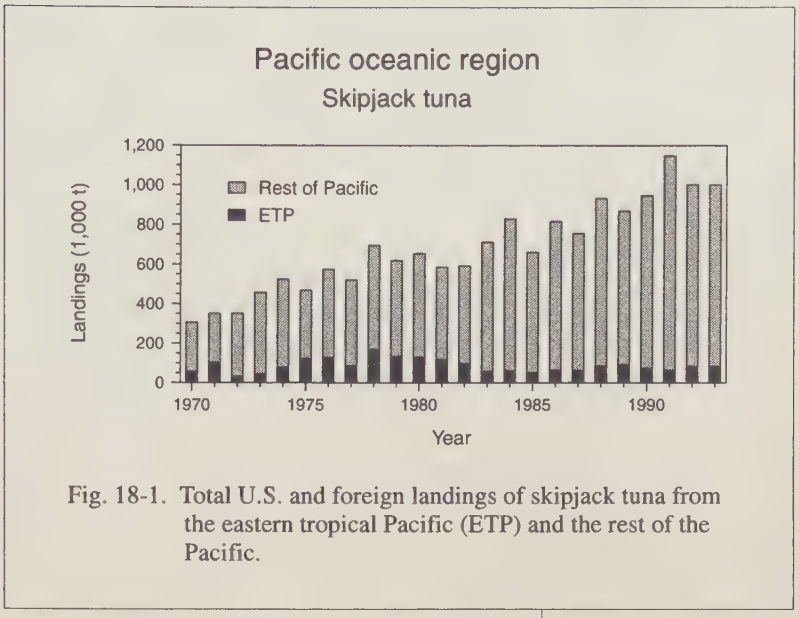


Fig. 18-1. Total U.S. and foreign landings of skipjack tuna from the eastern tropical Pacific (ETP) and the rest of the Pacific.

The RAY of bigeye tuna for the entire Pacific is about 152,000 t (Table 18-1) generating ex-vessel revenues of about $1 billion, with most of the catch taken by foreign longline fisheries. Bigeye tuna is mostly sold for raw consumption as "sashimi" and brings the highest dockside price of any tropical tuna (about $7,000/t). The best available estimates of LTPY and CPY are about 160,000 t (Table 18-1), and the current level of fishing effort is the highest recorded to date. Recent catch rates have been low but stable, and the stock may be fully utilized.

Albacore

Albacore is fished from the northern limits of the North Pacific Transition Zone (NPTZ) to about lat. 15°N, and from Japan to North America. In the South Pacific, it is fished from about lat. 15°S to the southern limits of the Subtropical Convergence Zone (STCZ) and from South America to Australia.

In the North Pacific, albacore is fished primarily by longline, pole-and-line, trolling, and until recently, drift gillnet. Longline gear is used in the lower latitudes and

E. Tropical Pacific Skipjack Tuna Landings (t)

1993 82,800
1994 83,800

Rest of Pacific Skipjack Tuna Landings (t)

1993 918,500
1994 917,500

E. Tropical Pacific Yellowfin Tuna Landings (t)

1992 331,300
1993 324,600

W. Central Pacific Yellowfin Tuna Landings (t)

1992 390,500
1993 397,000

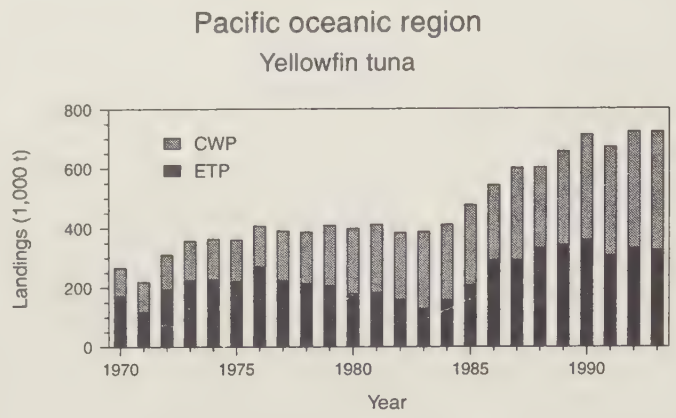


Fig. 18-2. Total U.S. and foreign landings of yellowfin tuna from the eastern tropical Pacific (ETP) and central-western Pacific (CWP).

North Pacific Albacore Tuna Landings (t)

1992	55,400
1993	44,200

South Pacific Albacore Tuna Landings (t)

1992	28,700
1993	26,800

accounts for about 20-25% of the current catches. The surface fisheries (pole-and-line, troll) operate in the higher latitudes of the NPTZ and account for 75-80% of the catches. The U.S. fishery in the North Pacific extends from the middle of the North Pacific to North America and uses between 500 and 2,000 vessels. Based on a dockside price of $2,200/t, the annual ex-vessel revenue of the North Pacific albacore catch is about $120 million.

South Pacific albacore is fished primarily by longline and trolling. As in the north, longliners operate nearer the equator than trollers. Surface gear is fished in the Tasman Sea and in the STCZ at about long. 160°W. In 1993, about 47 U.S. trollers fished the South Pacific.

Pacific albacore (both the north and south stocks) has a long history of exploitation (Fig. 18-3). Recent development of a large surface fishery in the South Pacific, in addition to the longline fishery, has changed the previous stock assessments from fully exploited, under a longline-only fishery, to unknown. No LTPY has yet been estimated, but a comprehensive assessment is needed due to the rapid expansion of the troll fishery and termination of the driftnet fishery in 1991.

In the North Pacific, the total catch, catch rates, and fishing effort in the U.S. troll fishery and the Japanese pole-and-line fishery have all been declining (Fig. 18-3). Previous assessments estimated LTPY near 120,000 t and stock production at or above LTPY in the 1970s. This high production, coupled with a drift gillnet fishery from 1980 to 1992 (for which statistics are incomplete), probably overutilized the stock. A comprehensive assessment is needed due to the changing fisheries.

Swordfish

Swordfish are distributed throughout the temperate, subtropical, and tropical waters of the Pacific. Much of the Pacific-wide catch is taken by the Japanese longline fishery directed at tunas, with the rest taken by surface gears such as harpoons, handlines, and until recently, drift gillnets. Coastal fisheries occur off the United States, Japan, Taiwan, Mexico, Chile, and Australia. The catch has increased throughout the 1980s and 1990s (Fig. 18-4), averaging about 29,000 t in recent years (Table 18-1).

The stock structure and status of Pacific swordfish stocks are unclear. Several studies suggest more than one Pacific stock. The most recent assessment assumed a single Pacific stock and suggested that the stock was somewhat underutilized. However this assessment was limited to data through 1980. More recent statistics on catch and effort are not available, but as total catch has increased so has the crude estimate of LTPY. The RAY for 1990-92 exceeds the estimated LTPY (Table 18-1).

From 1989-93, production from the U.S. domestic longline fishery in Hawaii increased rapidly reaching 6,100 t and an ex-vessel revenue of $26.8 million in 1993 (Fig. 18-4). The 1992 production represents 16% of the total Pacific production and 50% of the central-eastern North Pacific production. However, production in the Hawaii fishery declined to 3,100 t in 1994.

The production from the U.S. domestic gillnet and harpoon fisheries located primarily off California increased dramatically from 1975 to 1985, when a peak catch of 2,400 t was landed. The fishery currently lands about 1,000 t of swordfish annually which yields about $4.0 million in ex-vessel revenue annually.

Other Billfishes and Pelagics

Species included here are the blue, black, and striped marlins; sailfish, shortbill spearfish, wahoo, mahimahi (dolphinfish); and several

oceanic sharks (requiem, thresher, hammerhead, and mackerel). They generally range from North America to Asia and between the North and South Pacific STCZ's. They are generally more abundant near islands, continental slopes, seamounts, and oceanic fronts, and many are important to local economies. They are caught by foreign and U.S. fishermen, both sport and commercial.

U.S. commercial fishermen in the western and central Pacific primarily use longline, troll, and handline gear to catch marlins, spearfish, wahoo, and mahimahi. Recreational fishing gears include rod-and-reel and handline. Sharks are taken by longline around the Hawaiian Islands and by harpoon and drift gillnet off North America.

Because of the many species in this "other species" category, no accurate value can be calculated for the annual catch. However, the U.S. catch of blue and striped marlins is worth about $2,000/t ex-vessel, and the U.S. catch of wahoo and dolphinfish (mahimahi) is worth over $4,000/t.

Three species dominate the reported catches of "other pelagic species": blue and striped marlins and mahimahi. Pacific-wide shark catches in the "Carcharhinidae" and "requiem sharks" categories reported to the United Nations Food and Agriculture Organization total about 22,000 t per year, but pelagic shark catches are reported by only a few nations. The total Pacific harvest of pelagic sharks is unknown. Catches of "other species" by U.S. fisheries in the central and western Pacific increased steadily through the 1980s, leveling out in the 1990s, while catches by U.S. fisheries in the eastern Pacific have declined (Fig. 18-5).

The status of most species' stocks is unknown or uncertain. Assessments using data through 1985 indicated that striped marlin were utilized slightly below LTPY, and blue marlin was fished above LTPY; however, new data are needed to confirm or dispute these findings. The conditions of virtually all shark species remain unknown.

Issues

Management Concerns

The primary issue for the management of pelagic species in the Pacific is the lack of consensus on a comprehensive international plan for gathering and reporting statistics and for setting up a conservation and management group to encompass all interests. The poor quality of some data and the lack of current data in several fisheries prevents conducting accurate and up to date stock assessment, developing informed management options, and preparing pragmatic advice for rational exploitation of the resource.

W. Pacific Swordfish U.S. Landings (t)

1993	6,100
1994	3,100

W. Pacific Billfish and Shark U.S. Landings (t)

1991	3,100
1992	2,280

Within the U.S. EEZ of the central and western Pacific, including Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands, the Western Pacific FMC has developed, and the Secretary of Commerce has approved, an FMP for pelagic species. The FMP specifically addresses concerns about the expanded Hawaii longline fleet and the potential for interactions among longliners, trollers, and handliners by placing a cap on the number of permits issued to longliners and establishing nearshore zones closed to longlining. At the Council's behest, NOAA Fisheries implemented a mandatory logbook and reporting system in the region's domestic longline fleet to collect statistics for fishery monitoring. Research is underway to analyze the fishery statistics and evaluate the effectiveness of the longline fleet limits.

A new concern is the impact on the

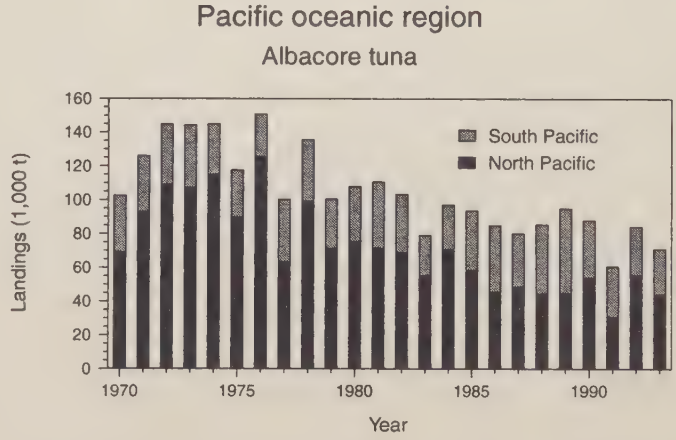


Fig. 18-3. Total U.S. and foreign landings of albacore tuna from the North and South Pacific regions.

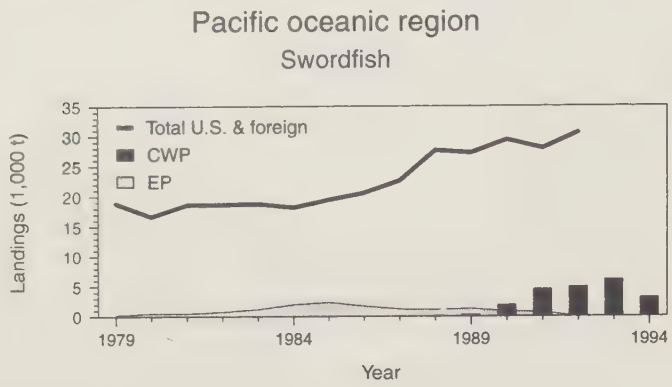


Fig. 18-4. Total U.S. and foreign landings of swordfish from the Pacific Ocean and U.S. landings from the eastern Pacific (EP) and the central-western Pacific (CWP) regions.

swordfish stock in the eastern and central Pacific of increased fishing effort due to the expanded Hawaii fishery and developing longline fleets based in California and Alaska. Proposed new controls may result in further expansion of the Hawaii-based swordfish fishery by allowing the smaller longliners that previously fished for tuna in the closed nearshore zones to upgrade their vessels for offshore swordfish fishing. Although fishing the same swordfish resource as the Hawaii-based

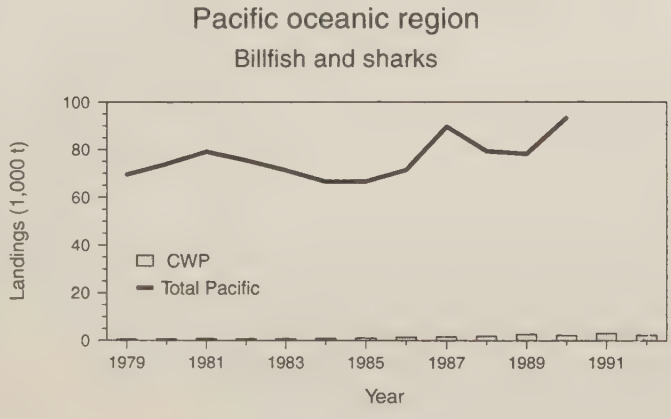


Fig. 18-5. Total U.S. and foreign landings of other pelagic species (billfish and sharks) from the central western Pacific (CWP) and total for the North Pacific Ocean.

vessels, longline vessels operating out of California and Alaska have not been subject to the management regulations developed by the Western Pacific FMC.

High-seas drift gillnet fisheries had taken a dominant share of the North Pacific albacore catch until their elimination in 1993. The full impact of the driftnet gear on the stock is not yet clear; however, data from the fisheries are being evaluated. In the South Pacific, the interaction between the established longline albacore fishery and a rapidly growing surface fishery (predominantly U.S.) needs attention, particularly if allocation of available yield between the fisheries becomes an issue. The scope, structure, and organization of a multilateral management regime is another issue which needs attention.

The North Pacific albacore stock appears to be overutilized, possibly due to the long period of heavy catches by drift gillnets. Further data collection and an evaluation of the effects of the drift gillnet fishery and other factors, including environmental changes, are urgently needed. Creation of an international forum to manage the stock is another issue that needs attention, particularly if the fishing nations want to reap the benefits of a recovered stock. Scientists recognize that at least one billfish species, the Indo-Pacific blue marlin is, and has been, depleted over its range, but no management mechanism exists to rebuild the stock. Similarly, thresher sharks and mako sharks taken in the west coast drift gillnet fishery may need protection from overexploitation.

The potential take of endangered Hawaiian monk seals and sea turtles is also of concern. The problem has been addressed by the Western Pacific FMC through a strict prohibition of longlining within a 50-mile area surrounding the Northwest Hawaiian Islands. Sea turtle bycatch is further investigated using data gathered by NOAA Fisheries observers on longline vessels.

Scientific Advice and Adequacy of Assessments

Population levels of the billfishes and other species are either unknown or out of date: There is no international mechanism to collect fishery data on the Pacific-wide stocks, including those portions of the stocks that range in the U.S. EEZ. Basic biological data (beyond catches) are also lacking or grossly inadequate for most of these species. This limits determination of the current condition of the stocks. Bycatch of these species in other fisheries is another issue.

The impacts of the increased U.S. longline fleet in the Hawaiian EEZ and the central Pacific

on swordfish and other resources are unknown, but the catches are being monitored, and research is under way to better assess the stocks.

Progress

Research has been focused on selected issues, and progress has been made for several species. However, on the whole, the number of species and issues remains more than can be addressed given current agency resources.

For CWP yellowfin tuna, a series of informal international scientific meetings are under way to assemble and organize needed statistics as a precursor for a comprehensive assessment. For albacore and other tuna and tuna-live species in the North Pacific, a multilateral scientific agreement is expected to be implemented in 1996.

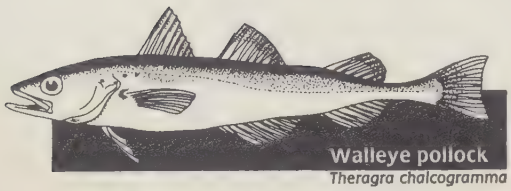
Management of the domestic fisheries has been successful in eliminating gear conflicts among longline, troll, and handline fisheries. Limited entry and area closures in the Hawaii longline fishery have stabilized or reduced the longline catch of yellowfin tuna, blue marlin, and other pelagic species important to nearshore troll and handline fisheries, thus reducing the potential for fishery interaction. At the same time, the total yield of the Hawaii longline fishery has increased due to a change in targeting from tuna to swordfish by some vessels, modifications of the seasonal limits of the area closures, and changes in areas of operations and species targeting by the tuna longline fleet. Area closures implemented in the northwest Hawaiian Islands to prevent interaction of the longline fleet with the endangered Hawaiian monk seal have been fully successful. ❑

Unit 19

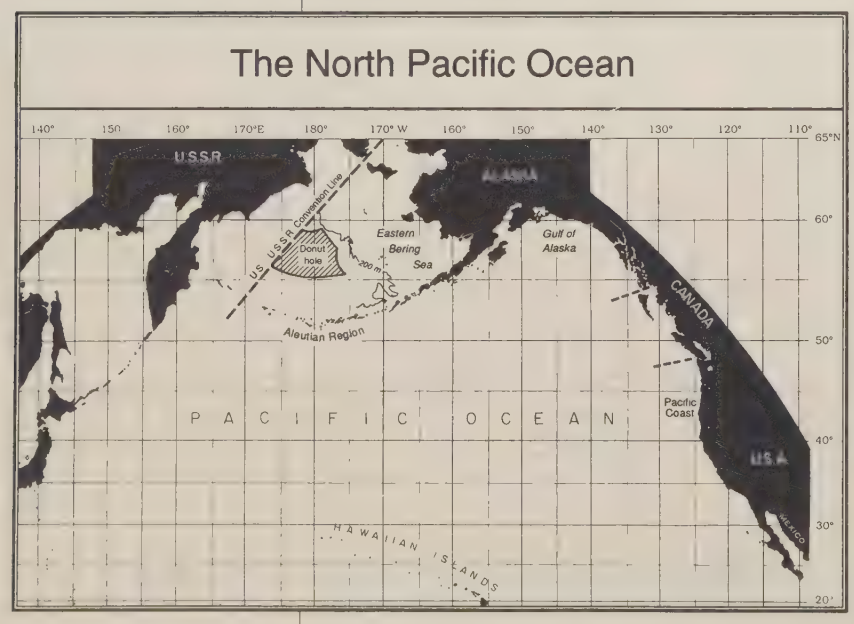
Alaska Groundfish Fisheries

Introduction

The groundfish complex off Alaska is the most abundant of all fisheries resources, not only for Alaska but for the entire United States as well. The resource base that total more than 20 million t of exploitable biomass contributes almost 2.2 million t of catch each year, with another 1.3 million t of underutilized sustainable potential.


Walleye pollock
Theragra chalcogramma

Prior to the implementation of the MFCMA in 1977, the only groundfish species of significant catch and value was Pacific halibut. All the rest of the groundfish species were virtually all utilized by foreign fisheries. The Act, that extended fisheries management jurisdiction to 200-nmi, brought into focus a vision and preference for domestic fisheries that led rapidly to the greatest success story of domestic fisheries participation and expansion for the country. The Alaska groundfish fishery is now a deeply rooted domestic industry. Much of the groundfish catches are exported, particularly to Japan, and such trade contributes prominently as a source of revenue to offset trade deficits for the nation.



Species and Status

Pacific Halibut

Pacific halibut is found from the Bering Sea to Oregon, with the center of abundance in the Gulf of Alaska. The resource is managed by treaty between the United States and Canada through recommendations of the International Pacific Halibut Commission. Pacific halibut is considered as one large interrelated biological stock; but is regulated by subareas through catch quotas, time-area closures, and (lately) by individual vessel quotas. The fishery has a long tradition that extends back to the late-1800s. There is a very active recreational fishery as well.

The 1993 Pacific halibut commercial catch was 35,435 t and worth $86.7 million dockside. The commercial catch was lower (33,100 t) in 1994 (Fig. 19-1), but worth more ($114.4 million). Other sources of catch were the recreational fishery (4,700 t), personal use (560 t), mortality due to fishing by lost gear and discards (1,700 t), and incidental catch by fishermen targeting on other species (9,700 t). About 4,630 vessels were licensed for the U.S. commercial fishery; but not all licensed vessels fished in 1994. The number of vessels licensed to fish in Canada was 435.

The exploitable portion of the Pacific halibut stocks apparently peaked at 270,000 in 1988-1990 (Fig. 19-1). The population has since declined at about 5% per year. Some decline is still expected, but halibut numbers are still fairly high by historical standards. The species is fully utilized.

Bering Sea-Aleutian Islands Groundfish

The average Eastern Bering Sea-Aleutian Islands groundfish catch during 1992-94 was about 1.9 million t (Table 19-2, Fig. 19-2). The total catch in 1994 was 1.86 million t, valued at $332 million (ex-vessel). The dominant species harvested were walleye pollock (1.28 million t valued at $210 million); Pacific cod (197,000 t valued at $65 million), and yellowfin sole (145,000 t valued at $18 million).

Groundfish populations have been maintained at high levels since implementation of the MFCMA. Their LTPYs total about 3.52 million t. The CPY of 3.07 million t for 1994 is slightly below LTPY. This potential, however, has not been fully utilized because catch quotas cannot be set to exceed the FMP 2.0 million t OY limit.

Walleye Pollock: Pollock produce the largest catch of any single species inhabiting the U.S. EEZ. The three main stocks, in decreasing order of abundance, are: Eastern Bering Sea (EBS) stocks, Aleutian Basin (AB) stock, and the Aleutian Islands (AI) stock. The EBS stock, sustained by the strong 1989 and 1992 year classes, is moderately high (near the level that produces LTPY) and fully utilized. The AI stock is believed to be in roughly the same condition as the EBS stock.

Until 1992, another large fishery targeted the portion of the AB stock residing outside of the U.S. and Russian EEZs in the "donut hole" of the central Bering Sea. Historical catches from this stock were apparently too high (well over 1,000,000 t throughout the late-1980s) and not sustainable. The abundance of the AB stock was consequently greatly diminished, and all fishing ceased in 1993.

Pacific cod: Pacific cod abundance remained high and stable throughout the 1980s. Although a string of below-average year classes (those spawned in 1986-88) led to a downturn in abundance during the early-1990s, this trend has been reversed due to a subsequent string of above-average year classes (those spawned in 1989-91). The cod stock is now healthy, increasing in abundance, and underutilized.

Flatfishes: All flatfish species are underutilized and, with the exception of Greenland turbot, high in abundance. The underutilization of flatfish results from the FMP requirement to maintain overall groundfish catches within the 2 million t OY cap and a desire to prevent excessive incidental catches of Pacific halibut and king and Tanner crabs. Yellowfin sole is the most abundant of the flatfishes. Within the overall groundfish complex, yellowfin sole ranks second in terms of abundance, behind walleye pollock. In terms of harvest, yellowfin sole ranks third among the groundfish complex behind pollock and Pacific cod. Greenland turbot, the only depressed flatfish stock, is expected to decline further during the rest of the 1990s as a result of poor recruitment.

Among the other flatfish species, abundance continues to be high and increasing for arrowtooth flounder and rock sole. It is high and stable for flathead sole, Alaska plaice, and other flatfishes. Rock sole is now the second most abundant of the flatfishes and the third most abundant of all groundfish species, having increased steadily from1975.

Sablefish: Sablefish (or blackcod) is a valuable species caught mostly with longline and pot gear in depths greater than those fished by trawlers. Sablefish is considered to be a single stock from the Bering Sea-Aleutian Islands (BSAI) region to the Gulf of Alaska. The BSAI population declined substantially in 1990, perhaps due to some migration into the Gulf of Alaska, and has remained at low-to-average levels since. Recent recruitment has been relatively weak. Sablefish is fully utilized.

Bering Sea/Aleutian Is. Groundfish Landings (t)

1993	1,854,100
1994	1,859,700

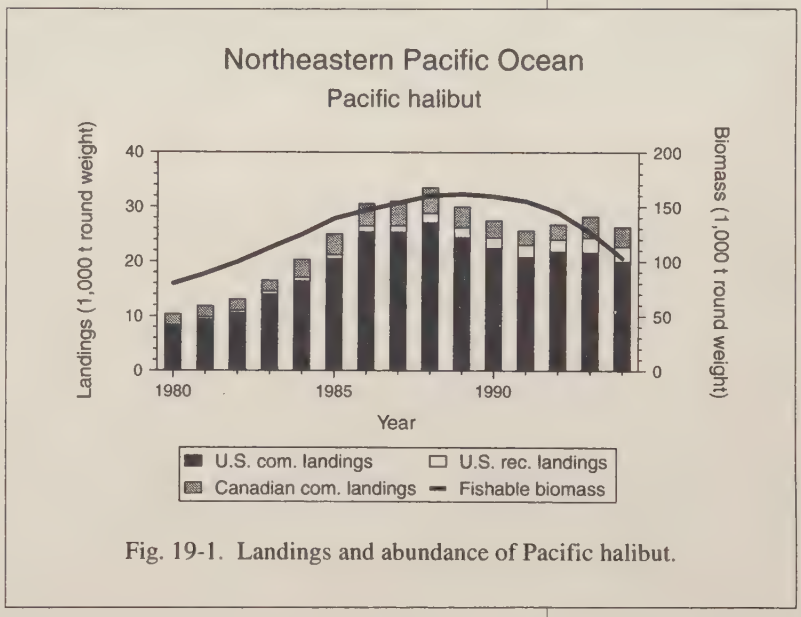


Fig. 19-1. Landings and abundance of Pacific halibut.

Canadian Pacific Halibut Landings (t)

1993	6,400
1994	6,000

U.S. Pacific Halibut Landings (t)

1993	29,300
1994	27,100

Rockfish: Rockfishes are assessed and managed as two major groups: Pacific ocean perch (POP) and "other rockfish." POP abundance dropped sharply due to intensive foreign fisheries in the 1960s and remained low into the early-1980s. In recent years, catch levels have been set well below CPY to help rebuild the stocks. The POP group is now recovering and is considered fully utilized.

Atka Mackerel: The Atka mackerel stock occurs mainly in the Aleutian Islands region. Previously, CPY for this species had been set conservatively low because of uncertainty regarding its abundance. However, trawl surveys conducted in 1986 and 1991 have confirmed a higher abundance than was previously realized, and a gradual increase in the rate of exploitation was phased-in from 1992. The stock is considered underutilized.

Other Species: In recent years, "other species" catches have represented 1% or less of the total groundfish catch. Sculpins and skates probably constitute most of this resource, but the abundance of pelagic squids, smelts, and sharks is largely unknown. The CPY has been set at the average catch level.

Table 19-1. Pacific Halibut

Productivity in metric tons and status of the fisheries resource

Area	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Bering Sea	3,600	3,600	2,900	Full	Below
Gulf of Alaska	25,700	17,600	14,200	Full	Near
Off U.S. Pacific Coast	200	300	200	Full	Below
Off Canadian Pacific Coast	5,400	5,700	2,700	Full	Near
Total	34,900	27,200	20,000		
U.S. Subtotal	29,500	21,500	17,300		

[1] RAY does not include 1,600 t for sport catch, bycatch, and waste.

Table 19-2. Bering Sea/Aleutian Islands Groundfish

Productivity in metric tons and status of fisheries resource

Species	Recent Average Yield (RAY)[1]	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Walleye pollock	1,359,912	1,421,600	1,880,000	Full	Near
Pacific cod	190,089	328,000	328,000	Under	Above
Yellowfin sole	132,433	277,000	277,000	Under	Near
Greenland turbot	7,186	15,800	18,500	Under	Below
Arrowtooth flounder	11,881	72,000	72,000	Under	Above
Rock sole	58,920	347,000	347,000	Under	Above
Other flatfish	31,154	255,000	255,000	Under	Above
Sablefish	2,432	3,800	3,800	Full	Near
Pacific ocean perch	16,571	20,640	20,640	Full	Near
Other rockfish	818	1,135	1,135	Under	Above
Atka mackerel	63,108	250,000	250,000	Under	Above
Other fish	27,898	30,710	30,710	Full	Near
Total	1,902,402	3,025,385	3,483,785		

[1] 1991-93 average.

Gulf of Alaska Groundfish

Groundfish abundance in the Gulf of Alaska increased from 1977 and reached a peak of 5.3 million t in 1982. Abundance since then has remained relatively stable, fluctuating between 4.5 and 5.3 million t. The estimated LTPY for Gulf of Alaska groundfish is 451,440 t (Table 19-3). The CPY is 492,240 t which reflects the high abundance of some stocks relative to their LTPY. The RAY is 249,580 t. The wide disparity between the CPY and the RAY is intentional because the trawl fishery, particularly for flatfish, is restricted by the North Pacific FMC to reduce incidental catches of Pacific halibut.

Gulf of Alaska groundfish catches have ranged from a low of 135,400 t in 1978 to a high of 352,800 t in 1984 (Fig. 19-3). The catches are dominated by pollock, followed by Pacific cod, flatfish, and sablefish. Catches since 1989 have fluctuated around 200,000 t. The 1994 groundfish catch of 238,122 t was valued at $114.5 million (ex-vessel value). Sablefish comprised about 54% ($61.6 million). Other major revenue-producing species in 1994 were pollock ($18.1 million), Pacific cod ($16.9 million), and flatfishes ($10.8 million).

Pollock: Pollock abundance has been declining in recent years due to poor recruitment trends. A conservative exploitation strategy is utilized for pollock to accommodate concerns about maintaining the pollock stock above threshold levels and ecosystem considerations, such as limiting forage fish removals (e.g. juvenile pollock) removals important to marine mammals and seabirds. Pollock are considered fully utilized.

Pacific Cod: Pacific cod are abundant and fully utilized, but are expected to decline due to a lack of significant recruitment. The last strong year class was the 1984 cohort. A conservative exploitation rate has been applied to Pacific cod in light of uncertainty about the magnitude of the population not sampled by the survey gear.

Flatfish: Flatfish are in general very abundant, largely due to great increases in arrowtooth flounder biomass. Flathead sole, rex sole and arrowtooth flounder are managed as separate categories, and the rest of the flatfish are managed as deepwater or shallow-water groups. Flatfish are underutilized due to halibut bycatch restrictions.

Sablefish: Sablefish are still considered to be abundant, although on a slow declining trend

due to a lack of strong recruitment. The resource is fully utilized. Sablefish became an Individual Fishing Quota (IFQ) fishery for the first time in the 1995 season. This will significantly change the dynamics of the fishery.

Rockfish: Slope rockfish are at low levels of abundance and fully utilized. Within the slope group, POP, shortraker and rougheye rockfish, and northern rockfish are managed as separate categories. The principal species of the slope group, POP, and shortraker and rougheye rockfish are highly valued. Rockfish, particularly POP, were intensively exploited by foreign fishing in the 1960s. Rockfish are long-lived, slow-growing fish that are only now showing signs of rebounding after heavy exploitation of three decades ago. A rebuilding plan is in effect specifically for POP. Thornyhead rockfish are also highly valued and believed to be at low abundance levels. They are conservatively managed due to their sensitivity to overexploitation. The abundance of pelagic shelf rockfish is unknown due to problems assessing this species with current methodology. Demersal shelf rockfish assessment and management are focused on the target species, yelloweye rockfish. Traditional population assessment methods (e.g. trawl surveys) are not considered useful for surveying these fish because of their affinity to rough terrain. They are currently being assessed using a manned submersible.

Atka mackerel: The Atka mackerel stock occurs mainly in the Aleutian Islands region. Its abundance in the Gulf of Alaska has been lower and highly variable. The resource supported a large foreign fishery in the Gulf through the mid-1980s but almost disappeared thereafter. Targeting on the species resumed in the Gulf in 1990, as the population increased.

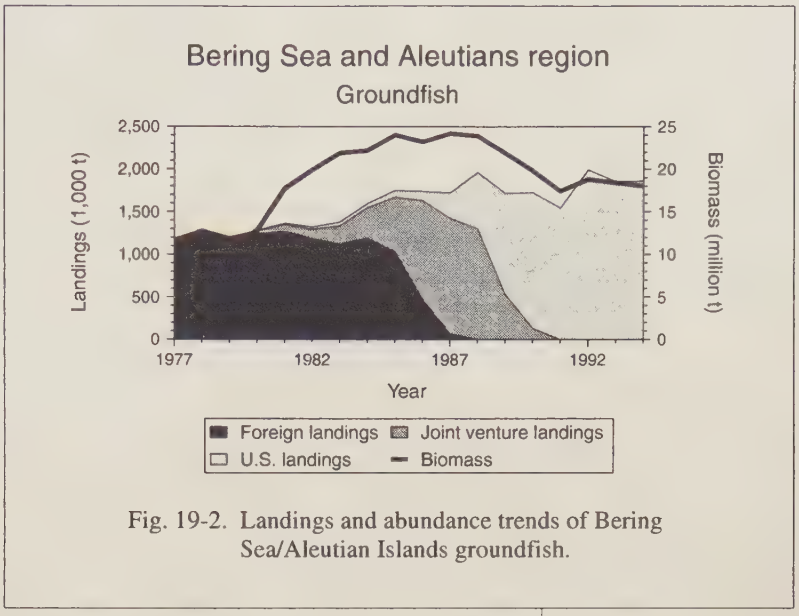


Fig. 19-2. Landings and abundance trends of Bering Sea/Aleutian Islands groundfish.

Issues

Transboundary Stocks and Jurisdiction

Large unregulated pollock fisheries in the donut hole of the Bering Sea was a major U.S. concern as migrating U.S. stocks outside the U.S. EEZ were targeted by foreign fishing vessels. Another concern was the lack of data to determine status of the stocks. Several international meetings were organized to develop cooperative research and management of the fishery. The user countries have now begun to cooperate on research and agreed to cease fishing in the donut hole area for 1993-95 due to extreme low abundance of the Aleutian Basin pollock stock.

In addition to the interjurisdictional problems posed by the donut hole fishery, it appears that a large component of the pollock population found in the northern Bering Sea, within Russian waters, is a continuation of the U.S. eastern Bering Sea shelf stock. As pollock abundance in the western Bering Sea has been decreasing, some Russian fishing effort have shifted towards the U.S.-Russia Convention Line. Thus pollock fishing on the Russian side of the Convention Line could impact the EBS shelf stock within the U.S. EEZ.

Gulf of Alaska Groundfish Landings (t)

1993	248,900
1994	238,100

Table 19-3. Gulf of Alaska Groundfish

Productivity in metric tons and status of fisheries resource

Species	Recent Average Yield (RAY)	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
Walleye pollock	104,507	65,360	169,000	Full	Below
Pacific cod	59,740	69,200	56,700	Full	Above
Flatfish	36,101	304,990	169,000	Under	Above
Sablefish	22,493	21,500	23,700	Full	Near
Atka mackerel	8,128	3,240	Unknown	Unknown	Unknown
Slope rockfish	13,390	20,280	Unknown	Full	Below
Thornyhead rockfish	1,413	1,900	3,750	Ful	Below
Pelagic self rockfish	3,261	5,190	Unknown	Unknown	Unknown
Demersal shelf rockfish	549	580	Unknown	Full	Unknown
Total	249,582	492,240	451,440		

Bycatch and Multispecies Interactions

Incidental catch of Pacific halibut, king and Tanner (snow) crabs, salmon, and other low abundance species taken in groundfish fisheries have remained difficult problems to resolve off Alaska. The problems have curtailed expansion of the groundfish fisheries. When any bycatch limit is reached, the groundfish fisheries would get closed down, usually before harvesting of the entire groundfish quotas.

Marine mammal interactions with fish and fisheries are a growing concern to resource management. Fisheries compete for fish that marine mammal and other species may depend on for food in the natural ecosystem. The impact of fish removals on Steller sea lions feeding has been postulated as an important factor for declining sea lion populations. The Steller sea lion is listed as threatened under the ESA and continues to decline in abundance. Since sea lions feed on juvenile pollock and other fish species, groundfish fisheries are being modified to reduce impact on them. For example, 20-50 mile closures around critical sea lion islands have been placed on fishing vessels to minimize disturbance of sea lion rookeries.

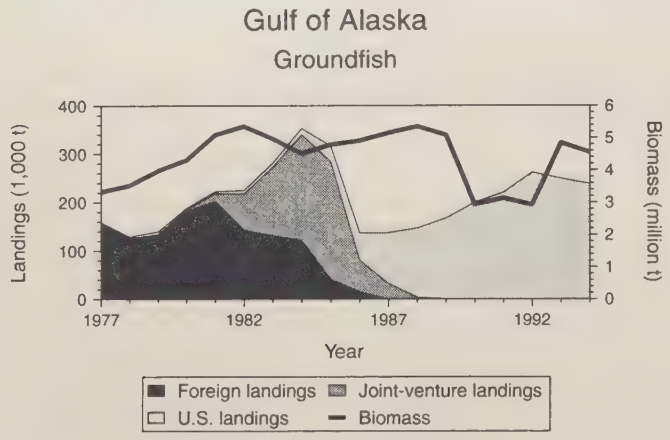


Fig. 19-3. Landings and abundance trends for Gulf of Alaska groundfish.

Progress

To minimize impact of unregulated pollock fisheries in the "donut hole" of the central Bering Sea, the U.S. reached an agreement with five other countries (Japan, Russian Federation, Poland, Korea, and China) to manage pollock fisheries and signed a Convention to the effect. This Convention was ratified in late-1995 and should provide more stability to the fisheries and allow the two coastal states, Russia and the U.S., more control of pollock fishing outside their 200-mile EEZs.

As the domestic groundfish fisheries are now fully developed and rapidly becoming overcapitalized, allocation disputes between user groups have been exacerbated. Significant problems include inshore vs. offshore, fixed gear vs. trawler, and other multi-user conflict issues. The North Pacific FMC has been addressing the problems as they arise. Recent FMP amendments have been implemented that have made explicit allocations to inshore and offshore sectors of the industry as well as setting specific percentage allocation of target and bycatch amounts to specific gear types. NOAA Fisheries has also promulgated regulations to implement an Individual Fishing Quota (IFQ) program for sablefish and Pacific halibut in 1995. Under the IFQ program, vessel owners are allocated transferable quota shares of the species to use at their discretion. It is expected that more efficient use of the resources will result..

Bycatch of nontarget species and adverse interactions with marine mammal populations by the groundfish fisheries are continuing problems off Alaska. These have been mitigated via a combination of regulations establishing bycatch limits, time-area closures, and special sea lion rookery protection zones. The North Pacific FMC has also been testing an incentive program to control bycatch. This is an individual vessel incentive program whereby bycatch rates are established for the fleet and regulated by individual vessels. It is designed to give a vessel more control over its own fishing destiny by holding it directly accountable for its bycatch rates. The program has resulted in some success and is under review. ❑

Alaska Shellfish Fisheries

Introduction

Alaska's major shellfish fisheries developed in the 1960s in the Gulf of Alaska, and subsequently expanded to the Bering Sea/Aleutian Islands region. Shellfish landings in 1993 generated an ex-vessel value of $328 million. The most important of these are the king, Tanner and snow crab fisheries at $304 million. Western Alaska shrimp resources remain depressed, and sea snails are essentially unharvested. Other miscellaneous invertebrate landings contributed about $21 million to ex-vessel revenue in 1993.

King and Tanner crab fisheries are managed primarily by the State of Alaska, with advice from a federal FMP for the Bering Sea and Aleutian Island stocks. The sea snail resource falls under management of a federal preliminary FMP. Shrimp and other near-shore fisheries are managed by the State of Alaska.

Species and Status

Crab

Three species of king crabs (red, blue, and golden or brown) and two species of Tanners (Tanner crab and snow crab) are harvested commercially off Alaska. Values for RAY, CPY, and LPTY are presented in Table 20-1. Information on CPY and LPTY is lacking for king and Tanner crabs; thus default values were derived from historical average landings. LTPY is represented by catch averages; CPY is set equal to RAY, calculated as the most recent three-year average. Stock status is determined by comparison of the short-term average catches against long-term production. The RAYs for king and Tanner crabs are below their respective LPTYs. By contrast, RAY for snow crabs is above its LPTY. Alaska crabs are fully utilized.

The ex-vessel value for king crabs in 1993 was $93 million, $45 million for Tanner crabs, and $165 million for snow crabs. Landings in 1994 were: king crab (5,640 t), Tanner crab (5,360 t), and snow crab (67,938 t). Almost all this production came from the Bering Sea, where value and landings were divided as follows:

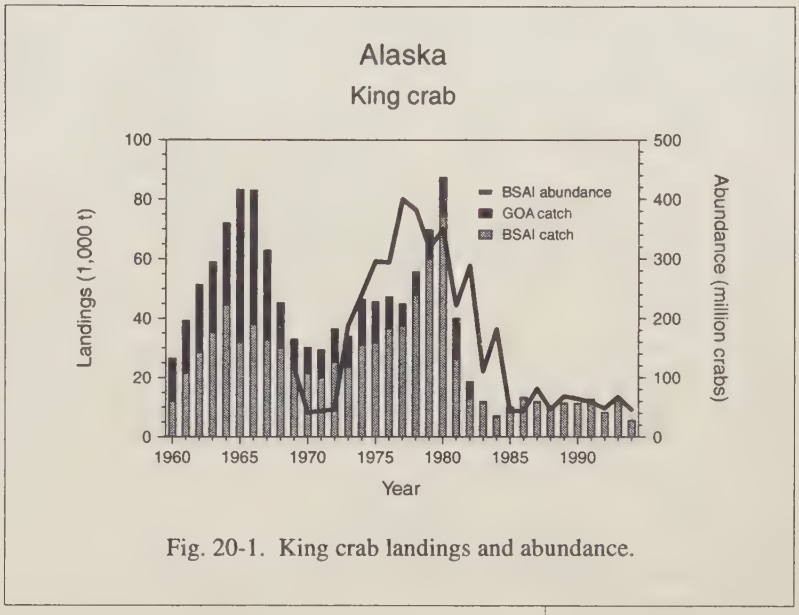


Fig. 20-1. King crab landings and abundance.

King crab ($87 million from 5,500 t) and Tanner crab ($40 million from 3,599 t). All snow crab landings came from the Bering Sea, and these dominated the total crab landings, comprising 55% of value and 88% of catch.

Alaska King Crab Landings (t)

	Bering Sea	GOA
1993	12,300	100
1994	5,500	140

The fleet fishing for Alaskan crab is comprised of 350-400 vessels, many of which are based in the Pacific Northwest. Crabs are captured with baited pots, and most of the catch is landed in Dutch Harbor, Alaska. Catches are restricted by quotas, seasons, and size and sex limits, with landings restricted to large male crabs. Fishing

Table 20-1. Alaska Shellfish

Productivity in metric tons and status of fisheries resource

Species	Recent Average Yield (RAY)	Current Potential Yield (CPY)	Long-Term Potential Yield (LTPY)	Fishery Utilization Level	Stock Level Relative to LTPY
King crabs	9,007	9,007	36,529	Full	Below
Tanner crabs	9,952	9,952	19,844	Full	Below
Snow crabs	105,214	105,215	36,980	Full	Above
Shrimps	1,500	1,500	15,675	Full	Below
Snails	71	Unknown	4,751	Under	Unknown
Total	125,744	125,745	113,779		

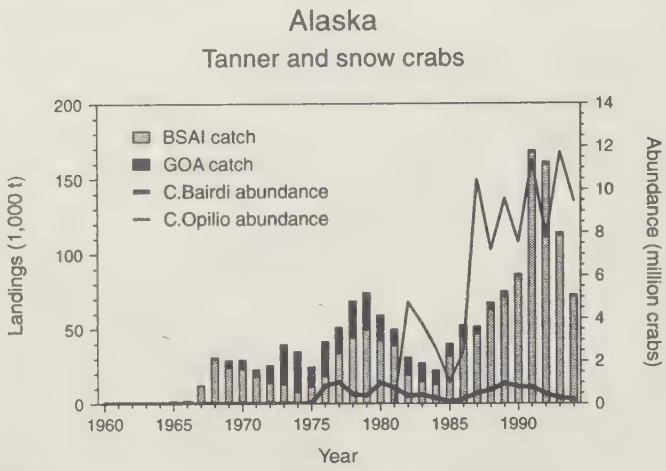


Fig. 20-2. Tanner crab landings and abundance.

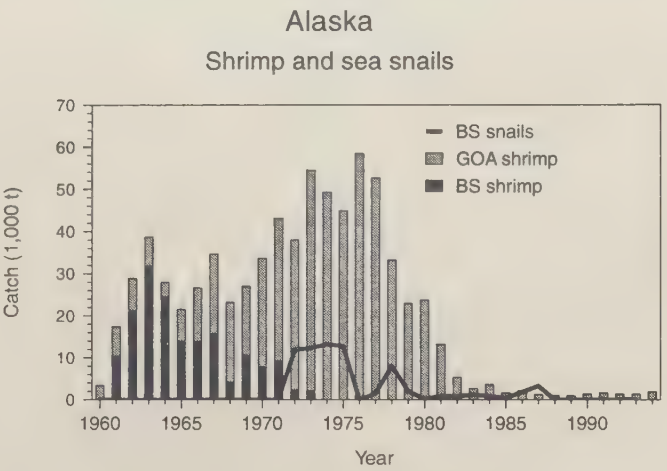


Fig. 20-3. Shrimp and sea snail landings.

Tanner Crab Landings (t)

	Bering Sea	GOA
1993	7,716	1,910
1994	3,599	1,760

Snow Crab Landings (t)

	Bering Sea	GOA
1993	104,700	0
1994	67,900	0

seasons are set at times of the year which avoid molting, mating, and soft-shell periods, both to protect crab resources and to maintain product quality.

Catch and abundance trends for king crabs are shown in Fig. 20-1. After a 1964-66 peak, declines were evident. Until 1967, Japanese and Russian fisheries dominated Bering Sea landings, but those fisheries were phased out by 1974. In the Bering Sea, domestic catches peaked at 74,000 t in 1980, dropped precipitously in 1981, and hit a low in 1984. Since then, the catch has been low and trendless. Gulf of Alaska catches peaked in 1965, then varied at a relatively low level for a decade before dropping lower still in 1983. Almost all Gulf king crab fisheries have been closed since 1983.

Tanner and snow crab trends are shown in Fig 20-2. The 1965-75 period was a developmental phase for the fisheries. During 1975-85, the catch peaked at about 75,000 t in 1979 and then declined. Since 1984 the catch increased, reaching an all-time high of 168,000 t in 1991, and then decreased into 1994. Abundance trends for Bering Sea stocks indicate that the Tanner crab stock declined from a relatively high level in the late-1970s to a low in 1985. The stock recovered and then declined again subsequent to 1989, and is currently at a low level. From a low in 1985, snow crab rebounded sharply, producing the high catches in 1991. A recent decline in the commercial stock has been masked by increasing numbers of pre-recruit males, which should provide improved catches in the next few years.

Shrimp and Sea Snail

The northern pink shrimp is the most important of the five species making up Alaska shrimp landings. The domestic shrimp fishery in western Alaskan waters is currently at a low level. Shrimp abundance is also too low in the Bering Sea to support a commercial fishery. The western Gulf has been the main area for shrimping. During the 1970s, when the fishery was more productive, 50-100 vessels trawled for shrimp at Kodiak and along the Alaska Peninsula.

Shrimp landings in the western Gulf during 1960-90 (Fig. 20-3) show that catches rose steadily to about 58,000 t in 1976 and then declined precipitously. Since 1988, negligible amounts have been landed. Ex-vessel revenue from the western shrimp fisheries averaged $4 million annually, and yielded a peak revenue of $14 million in 1977. Bering Sea shrimp catches by Russia and Japan peaked at 32,000 t in 1963, declining gradually thereafter, until the fishery ended in 1973. As with crabs, the potential yields of Alaska shrimp stocks are not well understood, and they have been equated to average catches. Shrimp are managed by regulating catch levels according to stock abundance. In addition, spring "egg hatch" closures are used to protect breeding stocks.

The Japanese fishery for snails, conducted

from about 1971 until ending in 1987, reached a peak of some 13,000 t in 1974. Catches averaged about 4,800 t during the period of the fishery. The snail stocks of the Bering Sea are underutilized because they are currently only lightly harvested, with four vessels participating in the Bering Sea. RAY and CPY equal the 1992-93 average catch, and LTPY equals the 1971-87 average.

Red king crab
Paralithodes camtschaticus

Issues and Progress

Bycatch and Multispecies Interactions

Alaska Shrimp Landings (t)

	Bering Sea	GOA
1993	0	1,320
1994	0	1,890

In general, crab and shrimp resources are down throughout Alaska. The red king crab stock in Bristol Bay is particularly low. For this reason, the fishery in Bristol Bay was closed in 1994 due to low spawning stock level.

The bycatch of crabs in trawl and pot fisheries continues to be a major issue. Not only is bycatch an allocation problem, but unknown mortalities from discards of crabs from pot and trawl catches could have an impact on the crab stocks. When crab abundance is low, bycatch mortality, added to directed fishing mortality, would impose unacceptable risks to stock recovery. ❑

Unit 21

Nearshore Fisheries

Introduction

For the purposes of this report, 'nearshore fishery resources' are those coastal and estuarine species found in the 0-3 nmi zone of coastal state waters, and for which NOAA Fisheries has no direct management role.

Nearshore resources vary widely in species diversity and abundance. Many are highly-prized gamefish. Others are small fishes used for bait, food, and industrial products. The invertebrate species of greatest interest include crabs, shrimps, abalones, clams, scallops, and oysters. Recent average yields from coastal state waters were at least 284,035 t (Table 21-1). This amount excludes landings of large-scale nearshore fisheries like anchovy, sardine, herring and the invertebrate resources described in earlier chapters.

Because the composition of the nearshore fauna is very diverse and management authority is shared among the many coastal states and other local bodies, OLO '95 does not attempt a detailed treatment of their status. However, this chapter presents information on the more significant species of national interest. For more comprehensive assessments of individual species, readers should refer to reports published by their state fish and game agencies.

Species and Status

Northeast Region

The 1992-94 RAY for the Northeast nearshore species was at least 75,200 t (Tables 21-1 and 21-2). This estimate is conservative because it only reflects commercial landings for most of the species owing to the lack of recreational harvest estimates for many, especially the invertebrates. The 1994 dockside revenue from the commercial landings was an estimated $175 million. Nearshore recreational value, though not available, is considered to be substantial.

Table 21-1. U.S. Nearshore Resources

Recent Average Yield in metric tons

Region	Recent Average Yield (RAY)
Northeast	75,230
Southeast	90,830
Alaska	3,210
Pacific Coast	113,245
Western Pacific	1,520
Total	284,035

Landings of blue crab are the most important of the nearshore species for the Northeast region (Table 21-2). Commercial landings in 1993 were 58,800 t, with an ex-vessel value of over $70 million. Abundance in Chesapeake Bay, the region's main producer, has declined due to heavy fishing and possibly predation on small crabs by striped bass and weakfish, both of which have increased in abundance. Blue crab commercial landings in 1993 were 58,800 t, with an ex-vessel value of over $70 million. In contrast to the Chesapeake, blue crabs have been unusually abundant in Delaware and Raritan Bays, where landings have increased.

Sea urchins, with the second highest landings of the Northeast nearshore species (RAY of 15,400 t), have been subjected to ever-increasing fishing pressure since a major fishery began in Maine waters in 1987 to supply a roe market in Japan. Landings increased from about 700 t in 1987 to 19,200 t in 1993. Abundance appears to have remained fairly level, although some local areas have now been fished out because of heavy harvesting conducted largely by divers resulting in a diversion of effort to other areas.

Oysters, one of the most valuable nearshore species (commercial landings valued at $37 million in 1993), have increased in abundance in Delaware and Chesapeake Bays, the two main areas of production. Production and landings in those areas had previously been severely depressed because of a high incidence of MSX and "dermo," two diseases which caused heavy mortality among oysters and caused a long-term decline in landings (Fig. 21-1). Below-normal salinity in the Bays and an unusually cold winter of 1993-94, which suppressed MSX and the incidence of "dermo," respectively, were associated with the recent increase in production. With Long Island Sound continuing to be the region's main producer of oysters, landings will likely increase over the next several years.

Landings and abundance of hard clams have remained level in the major producing

areas (Long Island Sound, Great South Bay, and Raritan Bay), but have declined in Narragansett and Barnegat Bays. Current levels of landings are about half of that in the early-1950s (Fig. 21-2). Ex-vessel value of landings has remained around $40 million in recent years. There has been substantial production in recent years from private hatcheries, about 20 of which exist from Massachusetts south.

Softshell clam landings have declined since the late-1960s (Fig. 21-2) and abundance has recently declined further in Maine and Maryland, the centers of main production. Reproduction of young clams has failed in northeastern Maine in recent years due to unexplained causes, while very high clam mortality occurred in Maryland in the early-1990s due to unusually hot summers. Abundance of juvenile clams has again increased in Maryland, and abundance of adult clams is fairly abundant in Massachusetts, Rhode Island, New Jersey, and eastern Long Island. Current landings are around 2,000 t and valued at nearly $20 million.

Abundance of blue mussels in nearshore areas of Maine and Massachusetts, which produce nearly all the landings for the region, has remained fairly stable in recent years. During the 1980s and early-1990s, landings increased markedly (Fig. 21-2). The principal source of landings during that period was a large bed east of Nantucket Island, which was harvested with dredges, until it was destroyed by a December 1992 storm. This loss has resulted in a drop in landings and a 50% increase in prices.

Bay scallop abundance in eastern Long Island and Rhode Island decreased sharply in the 1980s due to a dense algal bloom or "brown tide." Abundance subsequently increased in the 1990s in that area; abundance in Massachusetts has remained stable.

Conchs or whelks are harvested from Massachusetts through New York with pots and in Virginia with dredges. Landings have remained fairly stable, although the average size of the conchs has diminished in response to increasing harvesting. Periwinkles, harvested only in Maine, have declined slightly in abundance, with many easily accessible inshore areas depleted forcing fishermen to direct their efforts on ledges and islands further offshore.

Landings of Jonah and rock crabs have remained fairly stable, with abundance unknown but thought to be fairly high. Abundance of horseshoe crabs has declined in Delaware Bay, the site of greatest concentration and an intense fishery. They are either collected off beaches or taken by dredges.

Sea worms, dug principally in Maine, have declined both in abundance and in average size because of heavy harvesting. These worms are highly sought as bait by marine recreational fishermen from Massachusetts to South Carolina. Fishermen in Maine, who have traditionally been paid by weight landed, are currently demanding higher prices because of lower worm supplies.

A new fishery on sea cucumbers has begun in Maine to supply Asian markets. Abundance is presently high as fishing is being conducted on virgin stocks.

Of the finfish included in this group, only tautog has been assessed. Recreational fishing accounts for about 85% of the total landings, which have declined in recent years. Abundance

Table 21-2. Northeast Nearshore Resources

Productivity in metric tons and status of fisheries resources

Species / Group	Recent Average Yield (RAY)	Fishery Utilization Level	Stock Level Relative to LTPY
Blue crab	39,000	Full	Near
Sea urchins	15,400	Unknown	Unknown
Atlantic hard shell clam	4,000	Over	Below
Blue mussel	3,200	Unknown	Near
Tautog	2,800	Over	Below
Oysters	2,600	Over	Below
Softshell crab	1,900	Full	Below
Jonah crab	1,100	Unknown	Unknown
Rock crab	800	Unknown	Unknown
White perch	800	Unknown	Unknown
Conchs	700	Unknown	Unknown
Horseshoe crab	650	Unknown	Unknown
Sea cucumbers	600	Unknown	Unknown
Other shads and herring	550	Over	Below
American eel	400	Unknown	Unknown
Sea worms	400	Unknown	Unknown
Bay scallop	130	Over	Below
Periwinkles	100	Unknown	Unknown
Total	75,230		

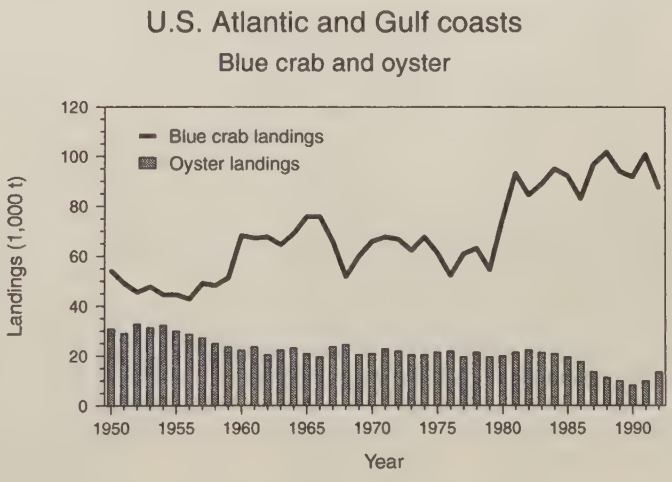


Fig. 21-1. Commercial landings of blue crab and oysters.

has also declined to record low levels in the past several years.

Southeast Region

Relatively few fisheries from the southeast are highlighted in this unit, as many of the truly nearshore fisheries of the region have been covered under Units 7, 9, 10, and 11. In the southeast as in the northeast, RAYs reported are underestimated, because they can generally be based only on commercial landings. Recreational landings, which may be considerable, are generally unavailable for the invertebrates that dominate the Southeast nearshore fisheries. Bycatch mortality is not estimated, or incompletely estimated, for many species.

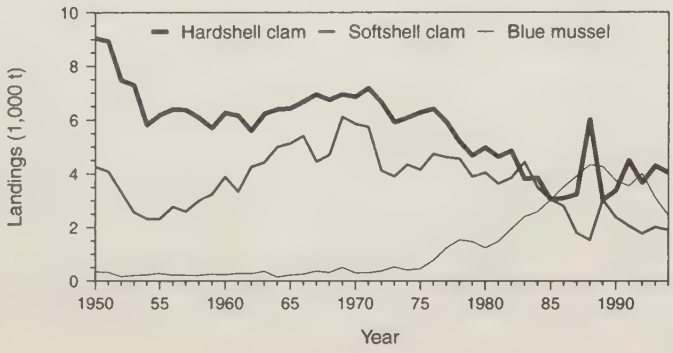


Fig. 21-2. Commercial landings of hard and softshell clams and blue mussels.

Blue crabs dominate the nearshore catch by weight. Recent landings have fluctuated around 60,000 t (Fig. 21-1, Table 21-3). Oyster harvest have trended downward over the last decade, with recent yields about 7,900 t. Calico scallop has been important in the landings in the past (20,000 t in 1984), but recent landings have averaged 830 t.

Mullet landings in the region have been stable at about 15,000 t. Commercial landings outweigh the recreational catch by about 14:1.

Table 21-3. Southeast Nearshore Resources

Productivity in metric tons and status of fisheries resources

Species / Group	Recent Average Yield (RAY)	Fishery Utilization Level	Stock Level Relative to LTPY
Blue crab	58,500	Full	Near
Mullet	14,730	Unknown	Unknown
Oysters	7,920	Over	Below
Bluefish	2,140	Unknown	Unknown
Calico scallop	830	Unknown	Below
Spanish sardine, herrings & butterfish	6,710	Unknown	Unknown
Total	90,830		

Bluefish landings have averaged 2,140 t; more than two-thirds are commercial and one-third recreational. Spanish sardine, herrings, and butterfish RAYs total about 6,700 t in the southeast. Virtually all of this catch comes from commercial landings. Breakouts by individual species are not possible due to confidentiality—several species are landed by only 1 or 2 firms. There are numerous baitfish fisheries in the region that are not generally or unevenly covered by the commercial statistics sampling program. Also, some nearshore species taken as bycatch in the shrimp fisheries are not accounted for in the sample collections. This discarded catch may be considerable.

Pacific Coast

California contributes the most commercial landings of nearshore species for the entire Pacific coast at more than 61,000 t (Table 21-4). This was followed by Washington (31,000 t) and Oregon (20,000 t). The total value of the fisheries, much of which is recreational, cannot be easily estimated but is thought to be sizable. Although not a direct measure of economic value, an estimated 2 million anglers, in California alone, spent $600 million each year on approximately 7 million fishing trips to catch nearly 30 million saltwater fish—most in nearshore waters. In addition to the many commercial nearshore species, anglers also land species that have been reserved exclusively for sport—such as striped bass, sturgeon, kelp bass and California corbina.

Shrimp resources—Shrimps support nearshore commercial fisheries throughout the Pacific region. They also provide for recreational fishing, especially near urban centers like in Puget Sound, Washington. The most common species harvested are pink, Pacific ocean, spot, side-stripe, and bay shrimps. In recent years, landings appear to be on a slight increase from a cyclic low (Fig. 21-3). Ridgeback, pink, and spot prawns are taken in California.

Crab resources—Dungeness crab is the most abundant crab harvested along the Pacific coast. Commercial fisheries operate along all the west coast states, with Oregon and northern California providing the bulk of the landings. Some recreation crabbing also occurs and is an important recreational and subsistence fishery to many ethnic groups. Like other crustacean resources, the abundance of Dungeness crab is highly variable. In recent years, abundance

seems to be on the increase from a low cycle. The productivity and status of the other crab resources, which tend to be localized, are largely unknown.

Abalone—Abalones are found mostly in California where utilization of the resource actually predates modern history. The meat is very valuable; a 14-ounce canned abalone may retail for $50.00 in Seattle's Chinatown. Five species are harvested; the more common include the red, green, and black abalones. The red abalone dominates the commercial catch. Harvesting is accomplished by "hooka" gear, where compressed air from the surface is supplied to the divers. Where allowed by law, recreational abalone-pickers use SCUBA gear, otherwise sport fishing is restricted to free diving and shore picking. In California, the use of SCUBA is illegal north of Yankee Point in Monterey Bay. At the present time, most of the species of abalones in central and southern California are overutilized. This is due to commercial harvesting efficiency, increased market demand, popularity of the sport fishery, habitat degradation, increasing predation by sea otters, and disease. At least part of the decline in landings may be attributed to the California statewide closure on sport and commercial take of black abalone, which was imposed in July 1993 to allow recovery for survivors of a disease known as withering syndrome, which continues to decimate black abalone populations. Despite increasing management, abalone stocks remain vulnerable to continued depletion. The history of catches shows a continually declining trend (Fig. 21-4).

Clams—Clam digging is a popular recreation for many families throughout the Pacific coast, and most are harvested this way. Many species are harvested: razor clam, littleneck clams, pismo clam, gaper clam, Washington clam, butter clam, geoduck clam, and others. The clam fisheries are regulated by open-and-closed seasons and by bag limits. The status of the stocks can be inferred from catch performance and would be expected to be known for localized areas only. Since the number of beaches and, thus, stocks are too numerous, it would be difficult to generalized on the status of the stocks. Thus status of the stocks and degree of utilization are largely unknown.

The Pacific geoduck is the largest burrowing bivalve on the Pacific coast. Individuals can live for more than 100 years and reach 9 kg. They are harvested both commercially and recreationally with the majority of the harvest coming from Puget Sound and British Columbia. Commercial harvest is by divers using high pressure jets to excavate the clams. In Puget Sound, the population between 10 and 30 m depth is estimated at 127,000 t, and the average annual commercial harvest is 1,300 t.

Squid—One species, the market squid, is harvested throughout the region, with California providing most of the catches. It is harvested for bait as well as for food. In southern California, squid is popular in local ethnic food markets and the restaurant trade. Squid jigging is also a popular winter activity in the Pacific Northwest. In this sport, anglers of all ages crowd under pier lights and jig for squid in the middle of cold winter nights.

Large-scale fluctuations are characteristic of the squid stock, due mainly, to its short life span and wide variations in ocean environment. This short life history, however, makes it possible for squid to recover after disasters as soon as ocean environment turns good again. Little is known about the biomass, structure, and status of the stock.

Sea Urchins—Commercial utilization of sea urchins in the United States is relatively recent in history; started essentially in the early-1970s for the roe or "uni" of red urchins, which is exported for the Japanese "sushi" market. In addition to red urchins, several other species are found in U.S. waters, but most are of little commercial importance due to the

Table 21-4. Pacific Coast Nearshore Resources

Productivity in metric tons and status of fisheries resources

Area / Species	Recent Average Yield (RAY)	Fishery Utilization Level	Stock Level Relative to LTPY
California			
California market squid	34,100	Unknown	Unknown
Sea urchins	12,500	Full	Near
Shrimps & prawns	6,000	Full	Near
Dungeness crab	4,800	Full	Near
Other crabs	620	Full	Unknown
Pacific bonito	650	Unknown	Unknown
Smelts & silversides	590	Full	Unknown
Elasmobranchs	420	Under	Near
California halibut	300	Under	Near
Sea cucumbers	270	Unknown	Unknown
Spiny lobster	240	Full	Unknown
Abalones	190	Over	Below
Croakers	170	Unknown	Unknown
Pacific barracuda	70	Unknown	Unknown
Bivalves	20	Unknown	Unknown
Other fish & invertebrates	500	Unknown	Unknown
California Total	61,440		
Oregon			
Shrimps	13,910	Full	Near
Dungeness crab	5,000	Full	Near
Sea urchins	1,040	Unknown	Unknown
Clams	60	Unknown	Unknown
Squids	60	Unknown	Unknown
Elasmobranchs	60	Under	Unknown
Sturgeon	110	Full	Near
Pacific herring	90	Full	Near
Smelts	5	Unknown	Unknown
Oregon Total	20,335		
Washington			
Shrimps	5,520	Full	Near
Dungeness crab	5,070	Full	Near
Geoduck clam	1,300	Unknown	Unknown
Other clams	8,680	Unknown	Unknown
Oysters	3,320	Unknown	Unknown
Scallops	40	Unknown	Unknown
Sea urchins	2,200	Unknown	Unknown
Elasmobranchs	1,550	Under	Unknown
Pacific herring	3,000	Full	Near
Smelts	30	Unknown	Unknown
Octopus	30	Unknown	Unknown
Washington Total	31,470		
Pacific Coast Total	113,245		

[1] 1992-94 average calculated from California Deparment of Fish and Game commercial catch statistical reports. This period encompasses the 1992-93 El Nino conditions off California.
[2] For example, species such as mako sharks are under to fully utilized; thresher and leopard sharks are fully utilized; and spiny dogfish is underutilized.
[3] Considered underutilized since the gillnet fishery directed for this species ended January 1994 south of Pt. Arguello, where 86% of the gillnet catch had been taken.

small size of their roe. Though limited fisheries for red urchins take place off Washington and Oregon, a major fishery occurs in California. The commercial fishery for red sea urchins began in southern California in 1971 as part of a NOAA Fisheries program to develop fisheries for underutilized species. In the late-1970s and 1980s the fishery expanded to northern California, and in 1990, the value of the catch (20,534 t) amounted to $24.7 million, making it the most valuable fishery in the state. Commercial divers dive for the species using "hooka" gear mainly within the 7-20 m depth range. The species is landed alive. The resource has been generally underutilized throughout the Pacific coast, except for selected commercial fishing areas. In southern California, the sea urchin resource remains productive, suggesting that the status of the stock there is still good. In other areas, however, like northern California and Baja California, the fisheries have been characterized by rapid growth and decline. These experiences suggest that local stocks can be rapidly overharvested.

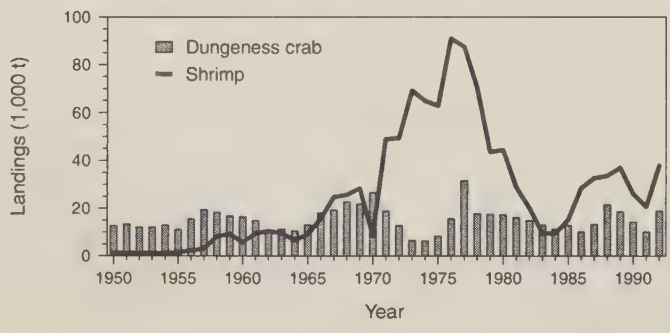


Fig. 21-3. Commercial landings of Dungeness crab and Pacific shrimp from the combined Washington, Oregon, and California region.

Sea cucumbers—Like sea urchins, sea cucumber emerged relatively recently as a commercial species in the late-1970s. The slimy, warty creature is harvested by trawl and by hand and processed into a dried product, primarily sold to the Asian market where it is a delicacy. In 1994, 89% of the California sea cucumber catch was landed by trawlers. There are a variety of species that are found from Washington to California; the species harvested in California are the giant red sea cucumber and the warty sea cucumber. Little is known about the abundance and status of the stocks. Sea cucumbers have a relatively short life span, a low maximum weight, a low age of first maturity, a high natural mortality and have highly fluctuating recruitment patterns. At the present low level of harvest, the resource appears not to be threatened at this time.

Elasmobranchs—Sharks, skates, and rays are taken commercially and recreationally and as bycatch in both segments of these fisheries. In certain areas they are taken as bycatch in commercial groundfish fisheries and swordfish fisheries. A growing number of incidental catches are landed for human consumption, but many are discarded at sea. Some are harvested for their fins to supply the Asian "shark's fin soup" market. Most of the elasmobranch species of higher recreational and commercial value are found in the warmer waters of southern California. Species taken include Pacific angel shark, leopard shark, thresher sharks, shortfin mako, blue shark, and cow sharks. Skates and rays are also harvested, often for their wings to supply the imitation "scallop meat" market.

Over the past two decades a tremendous amount of fishing pressure has focused on elasmobranchs. Just 15 years ago, the group was considered underutilized off California, but now, increased utilization for commerce and sport may have impacted the resources in localized areas. On the other hand, the total elasmobranch resource is thought to be underutilized throughout most of the Pacific coast states.

Although the life history characteristics of some the elasmobranch species are fairly well known, their abundance and status are largely unknown. Some species have wide geographical ranges that make stocks assessments difficult. Elasmobranchs generally have low reproductive potentials and slow growth rates, which make them vulnerable to rapid local depletion.

Smelts—Smelt resources in the region belong to two different families, Osmeridae (the true smelt) and Atherinidae (the silversides). There are a number of species of the two families. The resources provide for seasonal commercial and recreational fisheries for Washington, Oregon, and California. The resources are known for their migratory runs to coastal areas and rivers to spawn. They come en masse which makes them attractive targets for recreational and commercial fisheries. Some

smelt fishing is almost a ritual. Night smelt, for example, with its nocturnal habits are harvested during a brief spawning period by A-frame dip nets in the surf zone. Most are caught in the Eureka, California, area. The grunion (a species in the "smelt group") fishery is quite unique since fishers may use only their hands to grab the fish during their spawning runs on southern California beaches.

Despite their economic and social importance to humans and to ecologically related species as an important forage-base species, the abundance and status of many smelt stocks are still poorly known. Much is known of the species' biology and location and timing of the runs, but more is yet to be learned about the causes of population fluctuations and long-term trends.

Western Pacific Oceanic Region

Fisheries in the nearshore waters of the tropical and subtropical islands of Hawaii and the U.S.-associated Pacific islands are highly diverse though lower in aggregate volume than commercial or recreational fisheries of the United States mainland. Commercial landings are reported to be 1,500 t (Table 21-5). Many fisheries are unique to certain localities such as that for the palolo worm in American Samoa, seasonal fisheries for rabbitfish in Guam, and limpet (opihi) fisheries in Hawaii. Other fisheries are common to all islands, such as the fisheries for bigeye scad, called akule in Hawaii, atule in American Samoa, and atulai in Guam and the Northern Mariana Islands.

The more highly populated main Hawaiian Islands receive the heaviest inshore fishing pressure, with lighter pressure in the less densely populated islands elsewhere to the mostly uninhabited islands of the Northwestern Hawaiian Islands and the northern islands of the Commonwealth of the Northern Mariana Islands. In the main Hawaiian Islands, between 1980 and 1990 an average of 1,179 t of fishes and invertebrates were reported taken annually within 100 fathoms by commercial fishermen. According to the Hawaii Division of Aquatic Resources, the two pelagic carrangids, akule and opelu, support the largest inshore fisheries in the State. During the 1980-90 period annual commercial landings for these two species within three miles of shore averaged 184 and 113 t for akule and opelu, respectively. Other important commercial fisheries include those for surgeonfishes, squirrelfishes, parrotfishes, goatfishes, snappers; octopus, and various jacks or trevallies. There are significant recreational fisheries, but participation, landings, expenditures and economic values are not well documented. The recreational and subsistence component of Hawaii's marine fisheries was last assessed in 1986, when it was estimated that 200,000 trips were taken by 6,700 vessels involved in non-market fishing (which includes recreational, subsistence, and sub-market sales). Estimated landings by these "recreational" fishermen was 9,525 t (21 million pounds), of which 4,536 t (10 million lbs) were sold ($22 million). Total direct expenditures by these fisheries was $24 million, and the non-market value of the fishing experience was valued at $239 million.

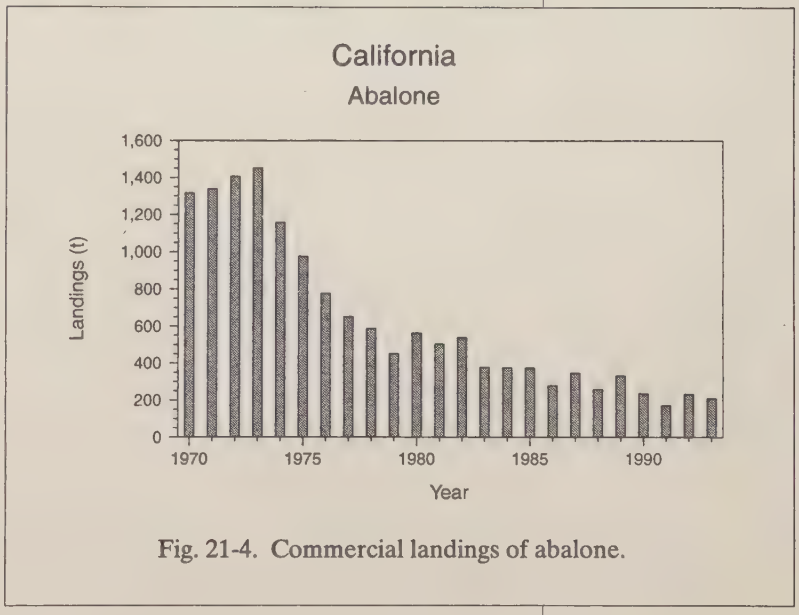


Fig. 21-4. Commercial landings of abalone.

The islands of American Samoa are partially surrounded by a narrow fringing coral reef which is inhabited by a diverse array of fishes and invertebrates. These are harvested by local residents on an almost daily basis. Total inshore subsistence catch was estimated in 1991 to be 207 t worth $798,000. The catch is dominated in some years by the coastal migrant atule, but other more resident species such as other jacks, surgeonfish, mullet, octopus, groupers, and snappers are most consistently taken. Samoans also fish on the predicted nights of emergence of the palolo worm, which is considered a delicacy (actually its reproductive segments or epitokes). For Samoan inshore

fisheries, downward trends in catch and catch per unit of effort have been observed in recent years, especially when the catches of the highly variable atule have been removed from the analysis.

Table 21-5. Western Pacific Nearshore Resources

Productivity in metric tons and status of fisheries resources

Area / Species	Recent Average Yield (RAY)	Fishery Utilization Level	Stock Level Relative to LTPY
Western Pacific Region			
Akule[1]	180	Full	Unknown
Opelu[1]	110	Full	Unknown
Other inshore fisheries[1]	880	Full	Unknown
Inshore reef fishes[2]	140	Full	Unknown
Inshore reef fishes[3]	210	Full	Unknown
Total	1,520		

[1] Main Hawaiian Islands (1980-90 average)
[2] Guam (1991)
[3] American Samoa (1991)

Guam is the southernmost and largest island in the Mariana Island Archipelago, and like American Samoa, the principal inshore fisheries are based on a wide assortment of coral reef fishes. Fishes taken are jacks and scads (especially atulai, the bigeye scad), surgeonfishes, squirrelfishes, fusilier, rudderfish (guili), snappers, mullet (aguas), goatfishes (Ti'ao), and rabbitfishes (mañahak). Invertebrate species include various marine crabs (including land crabs), spiny and slipper lobsters, sea urchins, octopus, squid, cuttlefish, tridacnid clams, topshell, chitons, conchs, strombids, and nerites. Guam inshore reefs appear to be fully exploited and have shown signs of overfishing. In 1991, the catch of nearshore reef fisheries was estimated at 140 t.

Alaska Region

Aside from salmon, crabs, shrimps, herring, and groundfish that support major fisheries both nearshore and at sea, nearshore resources have also provided subsistence and recreational fishing opportunities for Alaskans. Subsistence and recreational fishing are important activities and rights for Alaskans. The amount of nearshore resources harvested by the subsistence and recreational fisheries, however, has been difficult to compile. Excluding the recreational and subsistence catches of salmon and Pacific halibut, RAY is expected to be at least 3,000 t for the nearshore resource complex (Table 21-6). The component of the nearshore resources that have important commercial fisheries is the invertebrates. In declining order of mean percentage of landings since 1969, these include Dungeness crab, scallops, clams, sea cucumbers, sea urchins, abalone, octopus, squid and oysters.

Dungeness crabs are harvested nearshore by small boat commercial fleets and recreational fisheries primarily in the Southeast Alaska, Yakutat and Kodiak areas. About 30% of the U.S. production of Dungeness crabs traditionally comes from Alaska. Almost all Dungeness crabs (97%) are consumed domestically. The value and demand for the crab are normally high. Abundance of Dungeness crab resources are normally cyclic. In recent years, abundance off Alaska has been at the low end of a production cycle. Recent average yield has been about 2,000 t worth about $4.3 million.

The primary species of scallop harvested in Alaska is the weathervane scallop. The fishery was pioneered in 1967 and peaked in 1969 when 840 t of shucked scallop meat was landed. The principal harvest areas are Kodiak and Yakutat in the Gulf of Alaska, with Dutch Harbor (Bering Sea) as a new fishing ground. Harvesting is conducted by the same dredging gear and technique used in the New England scallop fisheries. While the status of the stocks are not well known, they are not believed to be large and are vulnerable to overfishing. Judging from recent landings which have been down, the status of the stocks may also be down. The fishery is regulated by the State of Alaska that limits the numbers of vessels and catch quota.

Sea cucumbers and urchins are recently developed fisheries. The first commercial landing of sea urchins was made in 1980 and that for sea cucumbers in 1983. Landings of urchins peaked at 212 t in 1992 and sea cucumber catch peaked at 100 t in 1990. They are harvested by divers and exported to Asian markets. Sea urchins are harvested and shipped live to Japan for their fresh roe. While the status of the stocks are largely unknown, their harvests are managed conservatively according to recent historical performances of the fisheries. The ADF&G surveys the resource periodically at selected sites to monitor major changes in relative abundance of the stocks.

The principal species of abalone harvested in Alaska is pinto abalone, taken almost exclusively from Southeast Alaska. Alaskan natives have a long history of harvesting abalone for food, trade, and shell ornaments. The commercial fishery, involving hand-picking by divers, is relatively young. Commercial catch peaked at 82 t in 1977 and RAY is only 23 t. Abalones are gourmet food and are normally exported to Japan. The status of the stocks is unknown and the fishery is regulated by ADF&G through monitoring of recent catch trends.

Issues

Habitat Concerns

Pollution, habitat degradation, disease, salinity and waterflow changes, and other environmental problems pose a continuous threat and concern for nearshore resources. The invertebrate species in particular and the fisheries on them are continually threatened by these problems which can contaminate the animals and prevent their sale for human consumption, or damage or destroy their habitat and the ability of the species to reproduce, grow, or survive. Excessive nutrient loads may increase toxic plankton blooms that cause "red tides" or "brown tides" and paralytic shellfish poisoning. The diseases MSX and "dermo" have destroyed millions of bushels of oysters in the Delaware and Chesapeake Bays since the late-1950s and have recently spread to coastal North Carolina where similar losses are occurring.

Salinity changes resulting from variable weather patterns can easily affect the survival of oysters both positively and negatively. Extreme low salinities in the upper portions of estuaries can kill oysters, while low salinities in the lower portions of estuaries can suppress the disease MSX and allow more oysters to survive.

Meso- to large scale climatic changes such as prolonged warmwater, nutrient-poor conditions stemming from tropical El Niños can depress resource production and confound recovery of some stocks while possibly aiding the recovery of others (e.g., Pacific sardine).

Management Concerns

Interspecific predation can affect the abundance of valuable species. For example, killifish, which are harvested for bait, prey on young softshell clams; scup, a target of both commercial and recreational fishermen, eat young bay scallops; blue crabs consume juvenile hard clams and oysters; ducks eat young softshell clams and mussels; striped bass and weakfish, highly sought by recreational fishermen, prey on small blue crabs; and horseshoe crabs, used as bait by conch/whelk fishermen and for medicinal/medical research purposes, consume young clams.

Harvesting practices for certain species can adversely affect the abundance of other important species. For example, people digging sea worms in Maine simultaneously kill many immature softshell clams, while fishermen dredging for blue mussels in sea worm habitat (mud flats) also destroy worms.

Table 21-6. Alaska Nearshore Resources

Productivity in metric tons and status of fisheries resources

Species / Group	Recent Average Yield (RAY)	Fishery Utilization Level	Stock Level Relative to LTPY
Dungeness crab	2,000	Full	Below
Scallops	570	Full	Unknown
Geoduck clam	70	Unknown	Unknown
Other clams	200	Unknown	Unknown
Sea urchins	100	Unknown	Unknown
Sea cucumbers	60	Unknown	Unknown
Abalone	20	Unknown	Unknown
Inshore fish	50	Under	Below
Other species	100	Unknown	Unknown
Total	3,170		

Most states have long-standing regulations governing the harvest of invertebrates. These regulations may restrict harvesting by means of seasonal and areal closures, minimum sizes, catch quotas, daily limits by individuals or boats, or by the numbers of licenses issued. ❑

Unit 22

Marine Mammals of the Alaska Region

Introduction

The Alaska region has 35 stocks of at least 25 species of marine mammals. Three of these species (sea otter, polar bear, and walrus) are managed by the U.S. Fish and Wildlife Service, and the remaining cetaceans and pinnipeds are managed by NOAA Fisheries. According to the criteria provided in the 1994 Amendments to the Marine Mammal Protection Act (MMPA), these include 9 strategic stocks: the Northern fur seal (which is depleted under the MMPA); the sperm whale, the western North Pacific and central North Pacific humpback whales, the fin whale, the North Pacific right whale, and the bowhead whale (listed as endangered under the ESA); and both the western U.S. and eastern stocks of Steller sea lions (listed as threatened under the ESA). Of the 35 stocks, five are believed to be increasing, ten are stable, two are declining, and the population status of the remaining 18 are unknown.

Three stocks, the Gulf of Alaska harbor seal and the Norton Sound and Cook Inlet beluga whales, are subject to subsistence harvests. While most marine mammal stocks are assessed under the authority of Section 117 of the MMPA, NOAA Fisheries determined that management of the stocks subject to subsistence harvests that do not have significant commercial takes should be developed through the co-management process described in Section 119 of the Act. The process should also include a sound research and management program to identify and address uncertainties concerning the stocks. Therefore, the required estimates of PBR and "strategic" determinations have not been made at this time for these three stocks.

Marine mammal stock status in the Aleutian region is summarized in Table 22-1. Important population parameters for the stocks and their status under the various protected species laws are included. A narrative for some selected stocks follows:

Table 22-1. Status of Marine Mammal Stocks in the Alaska Region

Species	Stock Area	N_{MIN}[1]	PBR[2]	Total Annual Mortality	Strategic Status[3]	MMPA/ESA Status[4]	Trend[5]
Steller sea lion	Western U.S.	42,536	766	555	Y	T	D
Steller sea lion	Eastern	23,533	1,059	8	Y	T	I
Northern fur seal	North Pacific	969,595	20,846	1,783	Y	D	S
Harbor seal	S.E. Alaska	32,745	1,965	1643			
Harbor seal	Gulf of Alaska	N/D	N/D	868	N/D		S
Harbor seal	Bering Sea	17,243	1,035	334			D
Spotted sea	Alaska	N/A	N/A	N/A			S
Bearded seal	Alaska	N/A	N/A	N/A			U
Ringed seal	Alaska	N/A	N/A	N/A			U
Ribbon seal	Alaska	N/A	N/A	N/A			U
Beluga	Beaufort Sea	38,194	764	160			U
Beluga	E. Chukchi Sea	3,710	74	65			S
Beluga	Norton Sound	N/D	N/D	147	N/D		S
Beluga	Bristol Bay	1,526	31	22			U
Beluga	Cook Inlet	N/D	N/D	N/D	N/D		S
Killer whale	AK & WA Inland Transient	759	7.6	0.8			S
Killer whate	AK & WA Inland Resident	245	2.4	0.8			U
Pacific white-sided dolphin	North Pacific	486,719	4,867	1.1			U
Harbor porpoise	Alaska	24,635	246	33			U
Dall's porpoise	Alaska	76,874	1,537	41			U
Sperm whale	Alaska	N/A	N/A	N/A	Y	E	U
Baird's beaked whale	Alaska	N/A	N/A	0			U
Cuvier's beaked whale	Alaska	N/A	N/A	0			U
Stejnerger's beaked whale	Alaska	N/A	N/A	0			U
Gray whale	E. North Pacific	21,715	434	0.3			I
Humpback whale	W. North Pacific	N/A	N/A	0	Y	E	U
Humpback whale	Central North Pacific	1,407	2.8	0	Y	E	I
Fin whale	North Pacific	N/A	N/A	0	Y	E	U
Minke whale	Alaska	N/A	N/A	0			U
Northern right whale	North Pacific	N/A	0	0	Y	E	U
Bowhead whale	Western Arctic stock	7,524					
Sea otter	Alaska	100,000					
Polar bear	Alaska-Chukchi-Bering Sea	N/A					
Polar bear	Alaska-Chukchi-Bering Sea	1,579					
Walrus	Alaska	188,316					

[1] N_{MIN} = Minimum population is estimated as the lower 20th percentile of the log-normal distribution of the population estimate, which is equivalent to the lower limit of a 60% two-tailed confidence interval.
[2] PBR = Potential biological removal.
[3] Strategic status: Y = yes, N/A = information is not available and N/D = estimated value has not been determined at this time.
[4] MMPA/ESA status: E = listed as endangered and T = listed as threatened under the Endangered Species Act.
D = listed as depleted under the Marine Mammal Protection Act.
[5] Trend is increasing (I), stable (S), decreasing (D), and unknown (U).

Steller Sea Lion: Western and Eastern North Pacific U.S. Stocks

Stock Definition and Geographic Range

Steller sea lions range along the North Pacific rim from northern Japan to California, with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands, respectively. The species is not known to migrate, but individuals disperse widely outside of the breeding season (late May-early July), thus potentially intermixing with animals from other areas. Two separate stocks of Steller sea lions are recognized within U.S. waters: an eastern stock, which includes animals east of Cape

Suckling, Alaska (144°W), and a western U.S. stock, which includes animals at and west of Cape Suckling. Steller sea lions in Canada are considered part of the eastern stock.

Population Size

The most recent estimate of Steller sea lion abundance in Alaska is based on aerial surveys performed in June 1994 from southeast Alaska to the western Aleutian Islands. The surveys counted animals, excluding pups, at 95 'trend sites', where sea lions have been monitored since the 1970s. A few additional sites were also surveyed in 1994. Differences between aerial and ship-based survey counts of the same areas were used to develop correction factors. Using these correction factors, the 1994 surveys estimated 43,200 Steller sea lions (33,600 nonpups and 9,600 pups) for the entire Gulf of Alaska, Aleutian Islands, and Bering Sea region that comprises the western U.S. stock . The estimate for the eastern stock from the southeast Alaska, California, and Oregon region was 23,900 Steller sea lions (18,600 nonpups and 5,300 pups). Aerial surveys in British Columbia during 1994 estimated 13,846 animals.

Minimum Population Estimate

Using the population estimate (N) of 43,200 and an associated CV of 0.0184, N_{MIN} for the western U.S. stock is calculated as 42,536 (Table 22-1). Similarly, the population estimate for the eastern stocks of 23,900 and an associated CV of 0.0184 gives a minimum population estimate of 23,533 sea lions.

Current Population Trend

Western Stock—The first reported trend counts (an index of population size) of Steller sea lions in Alaska were made during 1956-60 which indicated that there were at least 140,000 sea lions in the Gulf of Alaska and Aleutian Islands. Subsequent surveys indicated a major population decrease, first detected in the eastern Aleutian Islands in the mid-1970s. The decline appeared to have spread eastward to the Kodiak Island area during the late-1970s and early-1980s, and then westward to the central and western Aleutian Islands during the early and mid-1980s. The greatest declines occurred in the eastern Aleutian Islands and western Gulf of Alaska, but declines also occurred in the central Gulf of Alaska and central Aleutian Islands. Uncorrected counts from 1976-79 indicated about 104,000 sea lions. The western stock decreased 37.4% from 1989 to 1994. The 1994 estimate was 42,536 animals (Table 22-1).

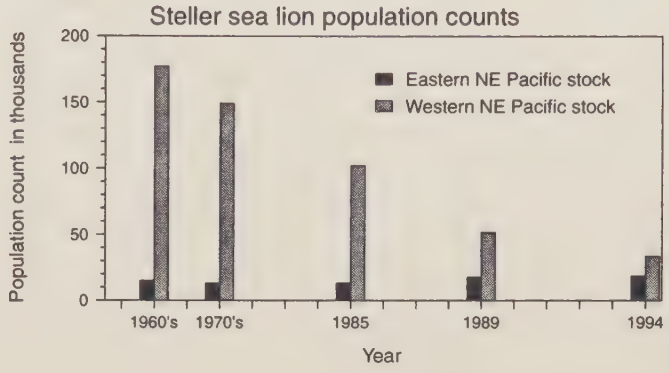


Fig. 22-1. Estimated population size of Steller sea lions (adults, juveniles, and pups) by the two U.S. stocks off Alaska.

Eastern Stock—Trend counts for Steller sea lions of the eastern stock have been relatively stable at about 2,000-3,000 animals (Fig. 22-1). The counts in Oregon have shown a gradual increase since 1976, as the adult and juvenile count for that year was 1,486 compared to 3,522 for 1994. This increase is likely due to a recovery from reduced numbers caused by mortality prior to 1972, as immigration from other areas has not been documented. Counts in California declined by over 50% from 5,000-7,000 between 1927 and 1947 to 2,000-2,500 between 1980 and 1990; limited information suggests that counts in northern California have increased from the late-1970s to the early 1990s. At Ano Nuevo, California, a steady decline in ground counts started around 1970, resulting in a 85% reduction in the breeding population by 1987. Based on data from vertical photography taken between 1990 and 1993, pup numbers declined at a rate of 9.9%, while nonpups declined at a rate of 31.5%. Most recently, population estimates for Steller sea lions in the eastern stock increased 5.8% from 1989 (22,600) to 1994 (23,533).

Steller Sea Lion Counts
(Pups Excluded)

Year	W. North Pacific (U.S. Stock)	E. North Pacific (U.S. Stock)
1960s	117,000	15,000
1970s	149,000	13,000
1985	102,000	13,200
1989	51,500	17,600
1994	33,600	18,600

Status of Stock

The Potential Biological Removal (PBR) for the western U.S. stock of Steller sea lions has been estimated at 766 animals, and PBR for the eastern stock at 1,059. The estimated annual level of total human-caused mortality and serious injury was 555 animals for the western stock and 8 for the eastern stock. Neither of the mortalities exceed the PBRs for these stocks. Both stocks of Steller sea lion are currently listed as threatened under the ESA, but the western stock is under consideration for endangered status. Thus, both stocks of Steller sea lions are classified as strategic stocks. Management actions recently implemented to reduce interactions with human activities include no-entry buffer zones around rookeries, prohibition of groundfish trawling within 10-20 nautical miles of certain rookeries, and spatial and temporal allocation of Gulf of Alaska pollock catches.

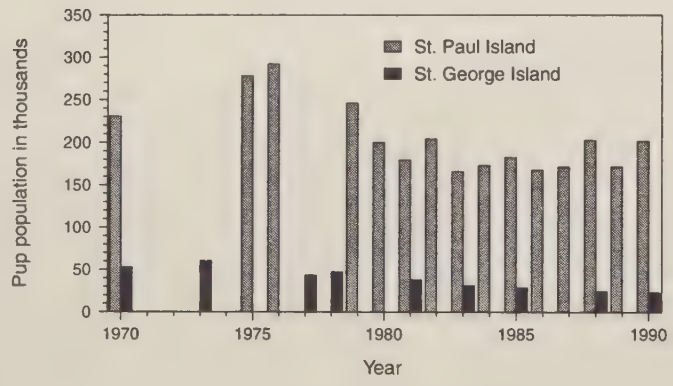


Fig. 22-2. Northern fur seal pup counts.

Northern Fur Seal: Eastern Pacific Stock

Stock Definition and Geographic Range

Northern fur seals occur from southern California north to the Bering Sea and west to the Okhotsk Sea and Honshu Island, Japan. During the breeding season, approximately 74% of the worldwide population is found on the Pribilof Islands in the southern Bering Sea, with the remaining animals spread throughout the North Pacific. Of the seals in U.S. waters outside of the Pribilofs, approximately 1% of the population is found on Bogoslof Island in the southern Bering Sea and San Miguel Island off southern California. Fur seals may temporarily haul-out onto land at other sites in Alaska, British Columbia, and on islets along the coast of the continental United States, but generally outside of the breeding season.

Adults usually occur on shore during a 6-month period, principally during the reproductive season (June-November), then migrate south and spend the next 6 months at sea. Adult females and pups from the Pribilof Islands migrate through the Aleutian Islands into the North Pacific, often to the Oregon and California offshore waters. Pups may remain at sea for 22 months before returning to their rookery of birth. Adult males generally migrate only as far south as the Gulf of Alaska. Two separate stocks of northern fur seals are recognized within U.S. waters: an eastern Pacific stock, and a San Miguel Island stock.

Population Size

The population estimate for the eastern Pacific stock of fur seals is calculated as the estimated number of pups at rookeries multiplied by a series of different expansion factors determined from a life table analysis to estimate the number of yearlings, 2-yr olds, 3-yr olds, and animals at least 4-yrs old. The expansion factors are based on a sex and age distribution estimated after the harvest of juvenile males was terminated. The resulting population estimate is equal to the pup count multiplied by approximately 4.475. As the great majority of pups are born on the Pribilof Islands, pup estimates are concentrated on these islands, though additional counts are made on Bogoslof Island. A total population estimate for the northern Pacific stock based on these pup counts in 1994 was 1,019,192 seals.

Minimum Population Estimate

Using the population estimate (N) of 1,019,192 and an associated CV of 0.0593 for pup counts, N_{MIN} for the eastern Pacific stock of northern fur seals is 969,595 animals.

Current Population Trend

The Alaskan population of northern fur seals recovered to approximately 1.25 million animals in 1974, after the killing of females in the pelagic fur seal harvest was terminated in 1968. The population first began to decrease with pup production declining at a rate of 6.5-7.8% per year into the 1980s; the total stock estimate in 1983 was 877,000. Annual pup production on St. Paul Island has remained relatively stable since 1981 (Figure 22-2), indicating that stock size has not changed much in recent years. The most recent stock estimates prior to 1994 were 984,000 in 1992, and 1.01 million in 1990. The northern fur seal was designated as depleted under the MMPA in 1988 because population levels had declined to less than 50% of levels observed in the late-1950s and there was no compelling evidence that carrying capacity (K) had changed substantially since the late-1950s. Under the MMPA, this stock will remain listed as depleted until population levels reach at least the lower limit of it's Optimum Sustainable Population, OSP (60% of K).

Status of Stock

The PBR for the eastern Pacific stock of northern fur seals is 20,846 animals. The estimated annual level of total human-caused mortality and serious injury is 1,783 seals, which does not exceed its PBR. The eastern Pacific stock of the northern fur seal is classified as a strategic stock because it is designated as depleted under the MMPA.

Bowhead Whale: Western Arctic Stock

Stock Definition and Geographic Range

Bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic, generally north of 54°N and south of 75°N in the Western Arctic Basin. Small stocks occur in the Sea of Okhotsk, Davis Strait, Hudson Bay, and Spitsbergen, but only a few tens to a few hundreds are found in each of these stocks. The largest remnant population is the western Arctic stock which migrates from wintering areas (November to March) in the northern Bering Sea, through the Chukchi Sea in the spring (March through June), to the Beaufort Sea where they spend much of the summer (mid-May through September) before returning to the Bering Sea in the autumn (September through November). The bowhead spring migration follows fractures in the sea ice around the coast of Alaska, generally in the shear zone between the shorefast ice and the mobile polar pack ice. There is evidence of whales following each other, even when their route does not take advantage of large ice-free areas, such as polynya. As the whales travel east past Point Barrow, Alaska, their migration is somewhat funneled between the shoreline and the polar pack ice, making for an optimal location from which to study this stock. Most of the year, bowhead whales are closely associated with sea ice. Only during the summer is this population in relatively ice-free waters in the southern Beaufort Sea, an area often exposed to industrial activity related to petroleum exploration.

Population Size

All stocks of bowhead whales were severely depleted during intense commercial whaling prior to the 20th century, starting in the early-16th century near Labrador and spreading to the Bering Sea in the mid-19th century. Prior to commercial whaling, the minimum world wide population estimate was 50,000 animals, with 10,400-23,000 in the Western Arctic stock. This population dropped to less than 3,000 when commercial whaling on this stock ceased at the end of the 19th century (Fig. 22-3).

Since 1978, counts of bowhead whales have been conducted from sites on sea ice north of Point Barrow, during the whales' spring migration. These counts have been corrected for whales missed due to distance offshore (through acoustical locators), whales missed when no watch was in effect (based on sighting rates), and whales missed during a watch (estimated as a function of visibility, number of observers, and distance offshore). However, in some years a small proportion of the population may not migrate past Point Barrow in the spring, therefore the estimate could be negatively biased. In 1993, unusually good counting conditions resulted in what is considered to be the most accurate population estimate to date for this stock: 8,000 bowhead whales (CV = 0.0730), with a 95% confidence interval from 6,900 to 9,200.

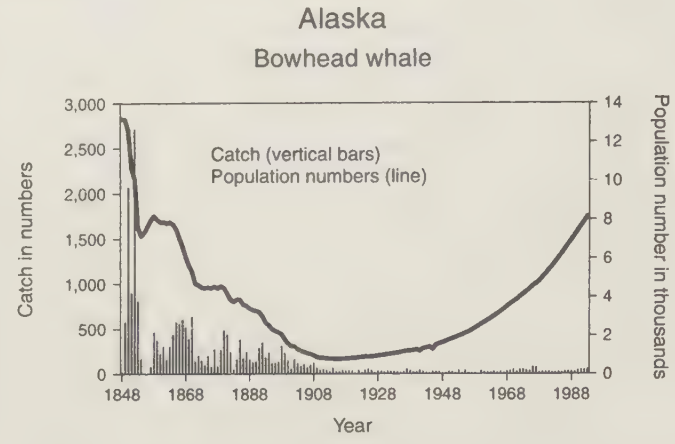


Fig. 22-3. Bowhead whale population trend and catch history.

Bowhead Whale Population Numbers

1987	5,364
1988	6,579
1993	7,770

Minimum Population Estimate

Using the population estimate (N) of 8,000 and its associated CV of 0.073, N_{MIN} for the western Arctic stock of bowhead whales is 7,524.

Current Population Trend

The western Arctic stock increased at a rate of 3.1% (95% CI = 1.4-4.7%) from 1978 to 1993, when abundance increased from approximately 5,000 to 8,000 whales. This rate of increase takes into account whales that passed beyond the viewing range of the observers.

Status of Stock

The PBR for this stock is 75 whales. The International Whaling Commission (IWC) independently established a quota for the number of bowhead whales to be taken by subsistence hunters, such that the number of whales struck cannot exceed 68 in 1995, 67 in 1996, 66 in 1997, and 65 in 1998. The IWC determination takes precedence over the U.S. PBR estimate for the purpose of managing the Alaska native subsistence harvest. The level of human-caused mortality and serious injury averaged over the past five years (42) does not exceed the PBR (75) nor the IWC quota for 1995 (68). Bowhead whales of the western Arctic stock are listed as endangered under the ESA and further classified as a strategic stock.

Beluga Whale: Beaufort Sea, Eastern Chukchi Sea, Norton Sound, and Bristol Bay Stocks

Stock Definition and Geographic Range

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere, and are closely associated with open leads and polynya in ice-covered regions. Depending on season and region, beluga whales in the western Arctic may occur in both offshore and coastal waters, with concentrations in Cook Inlet, Bristol Bay, Norton Sound, Kasegaluk Lagoon, and the Mackenzie Delta. It is assumed that most beluga whales from these summering areas overwinter in the Bering Sea. Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction. During winter, beluga whales occur in offshore waters associated with pack ice. In the spring, they migrate to warmer coastal estuaries, bays, and rivers for molting and calving. Annual migrations may cover thousands of kilometers.

Five putative stocks of beluga whales are recognized within U.S. waters: Cook Inlet, Bristol Bay, Norton Sound, Eastern Chukchi Sea, and Beaufort Sea.

Population Size

The sources of information to estimate abundance of belugas have included both opportunistic and systematic observations. The most recent survey conducted in 1992 for the Beaufort Sea stock resulted in an estimate of approximately 20,805 whales. A correction factor of 2 has been recommended for the Beaufort Sea stock, resulting in a current population estimate of 41,610. The estimated minimum size of the Eastern Chukchi stock of belugas is 1,200 based on counts of animals from aerial surveys conducted during 1989-1991. If this count is corrected for the proportion of animals that were diving and thus not visible at the surface, and for the proportion of newborns and yearlings not observed due to small size and dark coloration, the total corrected estimate for the Eastern Chukchi Sea is 3,710. The 1994 population estimate for Bristol Bay is 1,555, and for Cook Inlet Sound is 1,251. There currently is no population estimate for the Norton Sound stock.

Minimum Population Estimate

The minimum population estimates for Alaska beluga whale stocks are: 38,194 for the Beaufort Sea stock; 3,710 for the eastern Chukchi sea stock; and 1,529 for the Bristol Bay stock. Minimum population estimates have yet to be estimated for Norton Sound and Cook Inlet beluga stocks.

Current Population Trend

The Beaufort Sea stock of beluga whales is believed to be stable or increasing; the eastern Chukchi Sea, Bristol Bay, and Cook Inlet stocks are believed to be stable. The population trend for the Norton Sound stock is uncertain at this time.

Status of Stock

The PBR for Alaska beluga stocks are: 764 for the Beaufort Sea stock; 74 for the Eastern Chukchi Sea stock; and 31 for the Bristol Bay stock. PBRs have not been estimated for the Norton Sound and Cook Inlet stocks at this time. The levels of human-caused mortality and serious injury for these stocks averaged over the past five years are: 160 for the Beaufort Sea stock; 65 for the Eastern Chukchi Sea stock; 147 for the Norton Sound stock; 22 for the Bristol Bay stock; and is unknown for the Cook inlet stock. At this time, none of the three Alaska beluga whale stocks have been classified as strategic stocks under the MMPA. ❑

Unit 23

Marine Mammals of the Pacific Region including Hawaii

Introduction

The Pacific region has 66 stocks of at least 37 species of marine mammals. The U.S. Fish and Wildlife Service is responsible for managing two stocks of sea otters (Central California and Washington), while NOAA Fisheries has management authority for the remaining cetacean and pinniped stocks. According to the criteria provided in the 1994 amendments to the Marine Mammal Protection Act, these include 16 strategic stocks. In the eastern Pacific (i.e., waters of Washington, Oregon, California and Northern Mexico) the strategic stocks include: endangered sperm, humpback, blue, fin, and sei whales; short-finned pilot whales, Baird's beaked whales, Mesoplodont beaked whales, Cuvier's beaked whale, pygmy sperm whales, and threatened Guadalupe fur seals. Strategic stocks in Hawaiian waters include endangered blue, fin, and sperm whales, and Hawaiian monk seals. Of all the Pacific region stocks, 13 are believed to be increasing, 13 are believed to be stable, 4 are declining, and the trends of 36 stocks are unknown.

The status of marine mammal stocks in the Pacific region is summarized in Table 23-1. Important population parameters of the stocks and their status under the various protected species laws are included. A narrative for some selected stocks follows:

Table 23-1. Status of Marine Mammal Stocks in the Pacifc Region, including Hawaii

Species	Stock Area	N_{MIN}[1]	PBR[2]	Total Annual Mortality	Strategic Status[3]	MMPA/ESA Status[4]	Trend[5]
Sperm whale	CA/OR/WA	511	1.0	15	Y	E	S
Humback whale	CA/Mexico	563	0.5	1	Y	E	I
Blue whale	CA/Mexico	1,708	1.7	1	Y	E	I
Fin whale	CA/WA	575	1.1	1	Y	E	I
Brydes whale	E. Tropical Pacific	11,145	0.5	N/A			U
Sei whale	E. North Pacific	N/A	N/A	N/A	Y	E	U
Minke whale	CA/WA	265	2.6	0.5			U
Harbor porpoise	Central CA	3,430	34	31			D
Harbor porpoise	N. California	7,649	76	0			S
Harbor porpoise	OR/WA	22,049	220	14.2			U
Harbor porpoise	Inland WA	2,680	27	15			D
Dall's porpoise	CA/WA	58,902	589	36			U
Pacific white-sided dolphin	CA/WA	82,939	829	28			S
Risso's dolphin	CA/WA	22,388	224	39			U
Bottlenose dolphin	CA coastal	245	2.5	0			S
Bottlenose dolphin	CA/WA offshore	1,775	18	8			U
Striped dolphin	California	13,639	136	0			U
Common dolphin (short-beaked)	CA/WA	179,185	1,792	316			I
Common dolphin (long-beaked)	California	5,636	56	23			U
Northern right whale dolphin	CA/WA	15,080	151.0	46			U
Killer whale	CA/WA	139	1.4	0			U
Pilot whale (short-finned)	CA/WA	N/A	N/A	36	Y	M>PBR	U
Baird's beaked whale	CA/WA	19	0.2	2	Y	M>PBR	U
Mesoplodont beaked whale	CA/WA	136	1.4	8	Y	M>PBR	U
Cuvier's beaked whale	CA/WA	886	9.0	24	Y	M>PBR	U
Pygmy sperm whale	CA/WA	481	4.8	6	Y	M>PBR	U
Dwarf sperm whale	CA/WA	N/A	N/A	0			U
Brydes whale	Hawaii	N/A	N/A	0			U
Blue whale	Hawaii	N/A	N/A	0	Y	E	U
Fin whale	Hawaii	N/A	N/A	0	Y	E	U

...to be continued in next table...

[1] N_{MIN} = Minimum population is estimated as the lower 20th percentile of the log-normal distribution of the population estimate, which is equivalent to the lower limit of a 60% two-tailed confidence interval.
[2] PBR = Potential biological removal.
[3] Strategic status: Y = yes, N/A = information is not available and N/D = estimated value has not been determined at this time.
[4] MMPA/ESA status: E = listed as endangered and T = listed as threatened under the Endangered Species Act.
D = listed as depleted under the Marine Mammal Protection Act.
[5] Trend is increasing (I), stable (S), decreasing (D), and unknown (U).

Hawaiian Monk Seal

Stock Definition and Geographic Range

Hawaiian monk seals are distributed throughout the northwestern Hawaiian Islands (NWHI) in six main reproductive populations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll. The Midway population has not contributed significantly to pup production since the 1950s. Additional populations, with limited reproduction and maintained by immigration, are found at Necker Island and Nihoa Island, and a small number of seals are distributed throughout the main Hawaiian Islands.

In the last two centuries, this species has experienced two major declines which, presumably, have severely reduced its genetic variation. The tendency for genetic drift may have been (and continue to be) relatively large, due to the small size of the different island and atoll populations. However, 10-15% of the seals migrate among the different populations and, at least to some degree, this movement should counter the development of separate genetic stocks.

Demographically, the different island populations have exhibited considerable independence. For example, abundance at French Frigate Shoals grew rapidly during the 1950s to the 1980s, while other populations declined

rapidly. Current demographic variability among the island populations probably reflects a combination of different histories and varying environmental conditions. While management activities and research focus on single island and atoll populations, this species is managed as, and considered to be, a single stock.

Population Size

Total abundance of the Hawaiian monk seal was estimated to be 1,580 (SE=147) in 1992. Mean counts of animals found on beaches are used as the primary index of abundance. Between 1992 and 1993, the total mean count at the main reproductive population centers (excluding Midway) declined by 11%. If the decline in mean counts represent a similar decline in the total number of seals, then the best estimate of abundance for 1993 would be 1,406 (SE=131; assuming constant CV).

Minimum Population Size

Using 1,406 as the most current estimate of abundance, 131/1,406 = 0.093 as the coefficient of variation, the best estimate of N_{MIN} is calculated as 1,300 seals.

Current Population Trend

Between 1958 and 1993, mean beach counts at the main reproductive populations declined by 60% (Fig. 23-1). From 1985 to 1993, the counts declined by 5% per year.

Human-induced mortality has caused two major declines of the Hawaiian monk seal, and may continue to be an important factor impeding its recovery. In the 1800s, this species was decimated by sealers, surviving sailors of wrecked ships, and guano and feather hunters. A 1958 survey indicated at least partial recovery of the species in the first half of this century; however, subsequent surveys documented a second major decline beginning in 1958 (or earlier), during which several populations (Kure Atoll, Midway Atoll, and Pearl and Hermes Reef) decreased by 80-100%. Population trends at Kure Atoll, Midway Atoll, and French Frigate Shoals appear to have been determined by the pattern of human disturbance which, among other effects, caused pregnant females to abandon prime pupping habitat and nursing females to abandon their pups.

Since 1979, disturbance from human activities on land has declined, but disturbance at sea from fishing activities, may impede recovery. Development and expansion of fisheries during the 1970s in the NWHI has lead to interactions detrimental to monk seals. The interactions fall into four categories: operations and gear conflict, entanglement in fisheries debris, seal consumption of potentially toxic discard, and competition for prey. The Hawaiian monk seal interacts with four fisheries: the NWHI lobster fishery, the NWHI bottomfish fishery, the pelagic longline fishery, and recreational fisheries in the main Hawaiian Islands and at Kure Atoll.

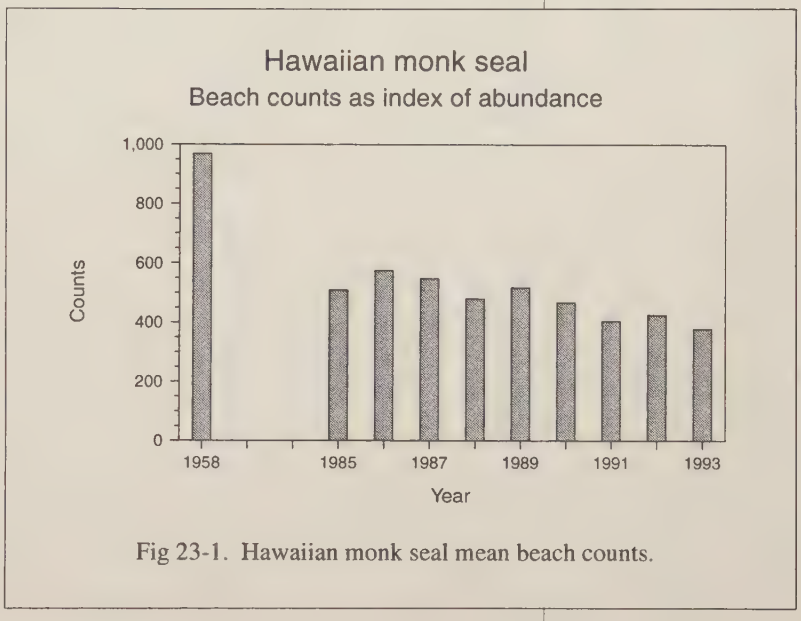


Fig 23-1. Hawaiian monk seal mean beach counts.

Status of Stock

In 1976, the Hawaiian monk seal was designated depleted under the MMPA and as endangered under the ESA. Under the methodology specified in the 1994 amendments to the MMPA and employing the values of N_{MIN} and R_{MAX} (1,300 and 0.06/yr, respectively), the calculated PBR is 3.9 seals. However, the ESA takes precedence in the management of this species and, under the ESA, the allowable take of monk seals is zero.

The species is assumed to be well below its OSP and, since 1985, has been declining at 5% per year. Therefore, this species is characterized as a strategic stock.

Harbor Porpoise: Central California Stock

Stock Definition and Geographic Range

In the Pacific, harbor porpoise are found in coastal and inland waters from Point Conception, California to Alaska and across to Kamchatka and Japan. Harbor porpoise appear to have more restricted movements along the west coast of the continental U.S. than along the east coast. Regional differences in pollutant residues taken from harbor porpoise indicate that they do not mix freely between California, Oregon, and Washington. The study also showed some regional differences within California (although the sample size was small). This pattern stands as a sharp contrast to the east coast of the U.S. and Canada where harbor porpoise are believed to migrate seasonally from as far south as the Carolinas to the Gulf of Maine and Bay of Fundy. Early genetic analyses did not show any significant differences between samples from California and Washington, but more recent analyses with larger sample sizes do show significant differences. These studies show that porpoises on the west coast are not panmictic or migratory, and movement is sufficiently restricted that genetic differences have evolved.

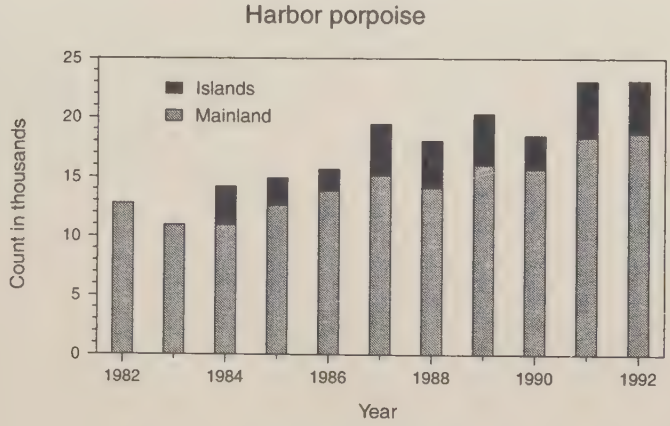


Fig. 23-2. Harbour porpoise counts.

In its harbor porpoise assessment, NOAA Fisheries recommended that the animals inhabiting central California (defined to be from Point Conception to the Russian River) be treated as a separate stock. The justifications given for this were: 1) fishery mortality of harbor porpoise is limited to central California, 2) movement of individual animals appeared to be restricted within California, and consequently 3) fishery mortality could cause the local depletion of harbor porpoise if central California is not managed separately. Because the recent genetic studies have confirmed that movement on the west coast is limited, harbor porpoise in central California is considered to be a separate stock. Other Pacific coast stocks of harbor porpoise include: 1) a northern California stock, 2) an Oregon/Washington coastal stock, 3) a Washington inland-waters stock, and 4) an Alaska stock.

Population Size

A 1994 review of previous estimates of harbor porpoise abundance in central California resulted in a new estimate of 4,120 (CV=0.22) based on a series of aerial surveys from 1988 to 1993. This recent estimate is not significantly different from the previous estimate of 3,274 (CV=0.31) but is more precise (owing to the greater number of kilometers surveyed). Both of these estimates only include the region between the coast and the 50-fathom (91m) isobath. In California, the vast majority of harbor porpoise are sighted within this depth range; however, 24% of harbor porpoise seen during aerial surveys of Oregon and Washington were between the 100m and 200m isobaths (55 to 109 fathoms). Thus, these abundance estimates are likely underestimates of the total abundance by a significant amount.

Minimum Population Estimate

The current minimum population estimate of 3,431 animals in central California is based on aerial surveys flown between 1988 and 1993.

Current Population Trend

Current estimates of population abundance trend are based on an analysis of a 1986-93 time series of abundance estimates from aerial surveys. The analysis found a statistically significant decline in harbor porpoise abundance in central California ($p < 0.1$) (Fig. 23-2). The decline is most evident in the southern part of central California, between Point Conception and Monterey Bay. There was no indication of

Table 23-1. (Contd.) Status of Marine Mammal Stocks in the Pacifc Region, including Hawaii

Species	Stock Area	N_{MIN}[1]	PBR[2]	Total Annual Mortality	Strategic Status[3]	MMPA/ESA Status[4]	Trend[5]
...continued from previous table...							
Pygmy killer whale	Hawaii	N/A	N/A	N/A			U
Pilot whale (short-finned)	Hawaii	N/A	N/A	N/A			U
Risso's dolphin	Hawaii	N/A	N/A	N/A			U
Killer whale	Hawaii	N/A	N/A	0.0			U
Melon-headed whale	Hawaii	N/A	N/A	0.0			U
False killer whale	Hawaii	N/A	N/A	N/A			U
Pantropical spotted dolphin	Hawaii	N/A	N/A	N/A			U
Striped dolphin	Hawaii	N/A	N/A	N/A			U
Spinner dolphin	Hawaii	677	6.8	1.0			U
Rough-toothed dolphin	Hawaii	N/A	N/A	N/A			U
Bottlenose dolphin	Hawaii	N/A	N/A	0.0			U
Pygmy sperm whale	Hawaii	N/A	N/A	N/A			U
Dwarf sperm whale	Hawaii	N/A	N/A	0.0			U
Sperm whale	Hawaii	N/A	N/A	N/A	Y	E	U
Cuvier's beaked whale	Hawaii	N/A	N/A	0.0			U
Blainville's beaked whale	Hawaii	N/A	N/A	0.0			U
California sea lion	U.S.	84,195	5,052	2,434			I
Harbor seal	California	32,800	1,968	729			I
Harbor seal	WA inland waters	13,053	783	14			I
Harbor seal	OR/WA	28,322	850	233			I
Northern elephant seal	CA breeding	42,000	1,743	166			I
Northern fur seal	San Miguel Island	10,536	227	0			I
Guadalupe fur seal	Mexico to CA	3,028	104	0	Y	T	I
Hawaiian monk seal	Hawaii	1,300	4.6	1	Y	E	D
Northeastern spotted dolphin	E. Tropical Pacific	648,900	6,489	934		D	D
W/S offshore spotted dolphin	E. Tropical Pacific	1,145,100	11,451	1,226			S
Eastern spinner dolphin	E. Tropical Pacific	518,500	5,185	743		D	S
Whitebelly spinner dolphin	E. Tropical Pacific	872,000	8,720	619			S
Common dolphin (northern)	E. Tropical Pacific	3,531,000	3,531	101			S
Common dolphin (central)	E. Tropical Pacific	297,400	2,974	151			S
Common dolphin (southern)	E. Tropical Pacific	1,845,600	18,456	0			S
Striped dolphin	E. Tropical Pacific	1,745,900	17,459	11			S
Coastal spotted dolphin	E. Tropical Pacific	22,500	225	N/A			S
Central American spinner dolphin	E. Tropical Pacific	N/A	N/A	11			S
Sea otter	Central CA				Y		I
Sea otter	WA						I

[1] N_{MIN} = Minimum population is estimated as the lower 20th percentile of the log-normal distribution of the population estimate, which is equivalent to the lower limit of a 60% two-tailed confidence interval.
[2] PBR = Potential biological removal.
[3] Strategic status: Y = yes, N/A = information is not available and N/D = estimated value has not been determined at this time.
[4] MMPA/ESA status: E = listed as endangered and T = listed as threatened under the Endangered Species Act.
D = listed as depleted under the Marine Mammal Protection Act.
[5] Trend is increasing (I), stable (S), decreasing (D), and unknown (U).

any compensating increase in porpoise abundance in northern California. The decline is somewhat surprising given that fishery mortality has been reduced during the same period.

Status of Stock

The PBR level for this stock of 34 animals is calculated as the product of the minimum population estimate (3,431), one-half the default maximum net growth rate for cetaceans (2%), and a recovery factor of 0.5 (for a species of unknown status).

Harbor porpoise in California are not listed as threatened or endangered under the ESA nor as depleted under the MMPA. Calculation of the status of harbor porpoise relative to historic carrying capacity suggests that the central California population could have been reduced to between 30% and 97% of its carrying capacity size (K) by incidental fishing mortality. Present information is insufficient to narrow the range of this estimate, and the status of harbor porpoise relative to their OSP levels in central California is unknown. The average mortality rate of 31 animals over the past 3 years is slightly less than the calculated PBR (34 animals) for central California harbor porpoise; thus, the central California harbor porpoise population is not considered a strategic stock. The MMPA Pacific Scientific Review Group recommended, however, that this stock placed in strategic status because it is in decline and may be listed as threatened unless this trend is stopped. Because fishery mortality has been reduced over the past 10 years and because there is some indication that the decline in animals may be due to natural causes, NOAA Fisheries does not believe that a strategic status is justified at this time. Research will continue to monitor this population size and to investigate the possible causes of its decline.

Humpback Whale: California/Mexico Stock

Stock Definition and Geographic Range

Four relatively separate migratory populations of Humpback whales have been identified in the north Pacific based on sightings of distinctively-marked individuals. These are the California/coastal Mexico stock, the Mexico offshore island stock (feeding destination unknown), the Hawaii/Alaska stock, and the Japan stock (feeding destination probably the Aleutian Islands). The California/Mexico stock ranges from Costa Rica to Washington state but is most common in coastal waters of California (in summer/fall) and Mexico (in winter/spring).

Significant levels of genetic differences exist between the California and Alaska feeding groups based on analyses of mitochondrial DNA and nuclear DNA. The genetic exchange rate between California and Alaska is estimated to be less than 1 female per generation. Genetic profiles from animal samples in the Hawaiian and Mexican breeding areas showed fewer genetic differences than did the two feeding areas. These differences are substantiated by the observed movement of individually-identified whales between Hawaii and Mexico. There has been no individual matches between 607 humpbacks photographed in California and 567 humpbacks photographed in Alaska. Few whales photographed in British Columbia have matched with a California photographic catalog, indicating that British Columbia is an approximate geographic boundary between feeding populations.

Population Size

Based on whaling statistics, the pre-1905 population of humpback whales in the North Pacific was estimated to be 15,000, but this population was reduced by commercial whaling to approximately 1,200 by 1966. The present North Pacific total certainly exceeds 3,000 humpback whales.

Population estimates for the "California feeding" stock ranges from 338 (CV=0.29) to 626 (CV=0.41). The most precise and least biased estimate is likely to be a 1994 mark-recapture estimate of 597 (CV=0.07) animals.

Minimum Population Estimate

The minimum population estimate for humpback whales in the California/Mexico stock from mark-recapture methods is approximately 563 humpback whales.

Current Population Trend

There is some indication that humpback whales have increased in abundance in California coastal waters between 1979/80 and 1991, but this trend is not significant. Mark-recapture population estimates have increased steadily

from 1988/90 to 1992/93 at about 5% per year. Although the North Pacific population is expected to have grown since it was given protected status in 1966, the possible effects of continued unauthorized take, incidental ship strikes, and gillnet mortality make this uncertain.

Status of Stock

The PBR level is estimated as 1.1 whales; however, because this stock spends approximately half its time in Mexican waters, the PBR allocation for U.S. waters is one-half of the PBR estimate, or 0.5 whales per year.

Humpback whales in the North Pacific were estimated to have been reduced to 13% of carrying capacity (K) by commercial whaling, and the population remains severely depleted. The population's initial abundance has never been estimated separately for the "California" stock, but this stock was also probably depleted by whaling. Humpback whales are formally listed as endangered under the ESA, and consequently the California/Mexico stock is automatically considered as a depleted and strategic stock under the MMPA. Although the estimated annual mortality due to entanglement (0.5/yr) plus ship strikes (0.7/yr) in California is greater than the estimated PBR level allocation of 0.5 for this stock in U.S. waters, the California/ Mexico stock appears to be increasing in abundance.

Eastern Tropical Pacific Dolphin

Approximately nine species of dolphins have been incidentally taken in the international fishery for yellowfin tuna in the tropical Pacific waters off Mexico and Central America (ETP area). Only four species (representing 10 stocks) have experienced significant mortality associated with the tuna fishery. Since these four species also occur in U.S. waters, and are impacted by U.S. fishing boats in the fleet, NOAA Fisheries has routinely assessed these dolphin populations.

The greatest mortality of dolphins occurred in the 1960s and 1970s, and led to dramatic declines in abundance of the northeastern spotted dolphin and eastern spinner dolphin stocks to one quarter of their pre-exploitation levels in 1959. Additionally, trend data collected since 1975 indicate both stocks are still significantly below the levels of 1975. In 1993, NOAA Fisheries listed both the northeastern offshore spotted stock and the eastern spinner stock as depleted under the MMPA because they were below their OSPs.

Although the greatest mortality occurred in the 1960s and 1970s, recent incidental mortality of ETP dolphins was still fairly high. For example, in 1986, a total of 133,174 dolphins was estimated killed, and, out of eight stocks for which a PBR level can now be calculated, seven had incidental mortalities that exceeded their PBRs. As recently as 1991, mortality in the three stocks of greatest concern (northeastern spotted, eastern spinner, central common) still exceeded their PBRs. These PBR comparisons are illustrative only, as the MMPA specifically manages ETP dolphins by quotas, not calculated PBRs. Incidental mortality of northeastern spotted dolphins increased in 1986 to 7% of their abundance estimate, a level that is not likely to be sustainable, and this apparently led to another significant decline in the stock between 1985 and 1994. The data also indicate that the central stock of common dolphins is still significantly below its 1975 level.

Mortality of ETP dolphins has been declining since 1986, and has decreased dra-

Table 23-2. Eastern Tropical Pacific Dolphins

Stock	Abundance (CV)	N_{MIN}	PBR[2]	Incidental Mortality in the Eastern Tropical Pacific Tuna Fishery		
Year(s)	1966-90	1986-90	1986-90	1992	1993	1994
Northeastern spotted[1]	730,000 (.142)	648,900	6,489	4,657	1139	934
West/South spotted	1,298,400 (.150)	1,145,100	11,451	1,874	757	1226
Coastal spotted	29,800 (.346)	22,500	225	N/A	N/A	N/A
Eastern spinner[1]	631,800 (.238)	518,500	5,185	2,794	821	743
Whitebelly spinner	101,9300 (.187)	872,000	8,720	2,044	412	619
Central American spinner	N/A	N/A	N/A	N/A	18	11
Northern common	476,300 (.367)	353,100	3,531	1,773	81	101
Central common	406,100 (.383)	297,400	2,974	1,815	230	151
Southern common	2,210,900 (.217)	1,845,600	18,456	64	0	0
Striped	1,918,000 (.112)	1,745,900	17,459	>112	17	11

[1] Listed as depleted under the Marine Mammal Protection Act.
[2] Comparison of recent incidental mortality to potential biological removal levels (PBRs) calculated for stocks of eastern tropical Pacific dolphins. It should be noted that ETP dolphins are explicitly excluded from management under the PBR section of the Marine Mammal Protection Act. Nonetheless, the calculated PBRs still provide a useful guide for intepreting the significance of dolphin mortality. Abundance estimates are from Wade and Gerrodette (1992). PBRs were calculated using an assumed maximum net productivity rate of 0.04 and a recovery factor of 0.5 in each case. Incidental mortality in boldface exceeds the PBR.

matically since 1991 (Table 23-2). A 1992 international agreement to manage the incidental mortality of ETP dolphins includes individual vessel quotas, that has led to a decrease in the total mortality of 3,796 dolphins of all species in 1994. Since 1992, the incidental mortality has been less than the estimated PBR for all stocks, and the annual incidental mortality of each stock is now less than 0.2% of their estimated abundance. Such low mortality rates should be sustainable and should, if continued, allow the northeastern spotted dolphin and the eastern spinner dolphin populations to increase and eventually recover.

There are still some uncertainties and concerns about the status of two small populations of endemic sub-species that are found in the ETP, the coastal spotted dolphin and the central American spinner dolphin. An abundance estimate is only available for the coastal spotted stock, which indicates that mortality of more than 225 animals per year may not be sustainable. No coastal spotted dolphins were reported killed in 1993 and 1994 (with near 100% observer coverage), although they have been reported killed in previous years. Additionally, 41 and 237 unidentified dolphins were reported killed in 1993 and 1994, respectively, indicating some kills may have occurred. Only 18 and 11 central American spinner dolphins were reported killed in 1993 and 1994, respectively. Monitoring of both of these coastal distributed stocks remains important, particularly if much fishing effort occurs close to the coast. ❑

Marine Mammals of the Atlantic Region including the Gulf of Mexico

Introduction

The Atlantic region has 62 stocks of at least 39 species of marine mammals. The U.S. Fish and Wildlife Service has management authority for two stocks of West Indian manatee (Florida and Antillean), and NOAA Fisheries has responsibility for management of the remaining cetacean and pinniped stocks.

According to criteria provided by the 1994 Amendments to the MMPA, there are 26 strategic stocks (Table 24-1). In the western North Atlantic, the strategic stocks include 6 stocks of endangered whales (right, humpback, fin, sei, blue, and sperm whales); the mid-Atlantic coastal bottlenose dolphin which is depleted under the MMPA; and 13 stocks where estimated mortality exceeds their PBRs (Cuvier's beaked whale, True's beaked whale, Gervais' beaked whale, Blainville's beaked whale, Sowerby's beaked whale, long-finned pilot whale, short-finned pilot whale, Atlantic white-sided dolphin, common dolphin, Atlantic spotted dolphin, pantropical spotted dolphin, mid-Atlantic offshore ottlenose dolphin, and the Gulf of Maine/Bay of Fundy harbor porpoise).

In the northern Gulf of Mexico, the strategic stocks include the endangered sperm whale, stocks of northern bottlenose dolphin in coastal bays and sounds, dwarf and pygmy sperm whales, and the Florida and Antillean stocks of endangered West Indian manatees. Of these stocks, North Atlantic right whales are believed to be increasing, mid-Atlantic coastal bottlenose dolphins are believed to be stable, West Indian manatees are believed to be declining, and the trends for the remaining 54 stocks are unknown.

Bottlenose Dolphin: Gulf of Mexico, Bay, Sound and Estuarine Stocks

Stock Definition and Geographic Range

Studies relying on identification of individual dolphins suggest that bottlenose dolphins inhabiting many of the bays, sounds, and other estuaries adjacent to the Gulf of Mexico form discrete communities. Although breeding may occur between adjacent communities, the geographic nature of these areas suggests that each community exists as a functioning unit of its ecosystem and, under the MMPA, must be maintained as such. Therefore, each of the areas forming a contiguous, enclosed or semi-enclosed body of water is considered to contain a distinct bottlenose dolphin stock.

Mark-recapture studies using photo-identification of individual dolphins in the vicinity of Sarasota and Tampa Bays in Florida showed that individual dolphins remain in a given area year around. Three distinct dolphin "communities" have been described in the area in and around Sarasota Bay. One community was formed by dolphins residing in the Gulf of Mexico coastal waters, another consisted of the dolphins in the deep water areas of Passage Key Inlet and Tampa Bay (adjacent to Sarasota Bay), and a third community resided in the shallow waters of Sarasota Bay.

Electrophoretic isozyme analysis showed significant differences between dolphins of the shallow-water Sarasota community and the Tampa Bay community, and from dolphins from Charlotte Harbor, to the south; however, there was a high degree of genetic heterozygosity indicating that the Sarasota community was not genetically isolated. It has been suggested that the Sarasota community is likely one of a number of communities which comprise an extended population, the limits of which are unknown. The continuous distribution of bottlenose dolphins around the Gulf of Mexico coast theoretically allows genetic exchange between adjacent communities; however, the females of the highly-structured Sarasota community form a stable, discrete, long-term breeding unit with strong geographical fidelity.

Recent photo-identification and radio-tracking studies confirmed that some individual dolphins remain in the same general areas within Matagorda Bay, Texas, throughout the year; thus, the situation there may be similar to that of the Florida west coast. Movement of resident bottlenose dolphins in Texas through passes linking bays with the Gulf of Mexico appears to be relatively limited, but does occur and suggests that these stocks may not be

Table 24-1. Status of Marine Mammal Stocks in the Atlantic Region, including the Gulf of Mexico

Species	Stock Area	N_{MIN}[1]	PBR[2]	Total Annual Mortality	Strategic Status[3]	MMPA/ESA Status[4]	Trend[5]
North Atlantic right whale	W. North Atlantic	295	0.4	2.5	Y	E	I
Humpback whale	W. North Atlantic	4,848	9.7	1	Y	E	U
Fin whale	W. North Atlantic	1,704	3.4	N/A	Y	E	U
Sei whale	W. North Atlantic	155	0.3	0.3	Y	E	U
Minke whale	E. Coast Canada	2,053	21.0	2.5			U
Blue whale	W. North Atlantic	N/A	N/A	0	Y	E	U
Sperm whale	W. North Atlantic	226	0.5	1.6	Y	E	U
Dwarf sperm whale	W. North Atlantic	N/A	N/A	N/A		?	U
Pygmy sperm whale	W. North Atlantic	N/A	N/A	N/A		?	U
Killer whale	W. North Atlantic	N/A	N/A	0			U
Pygmy killer whale	W. North Atlantic	6	0.1	0			U
Northern bottlenose whale	W. North Atlantic	N/A	N/A	0			U
Cuvier's beaked whale	W. North Atlantic	N/A	N/A	34	Y	M>PBR	U
True's beaked whale	W. North Atlantic	N/A	N/A	34	Y	M>PBR	U
Gervais' beaked whale	W. North Atlantic	N/A	N/A	34	Y	M>PBR	U
Blainville's beaked whale	W. North Atlantic	N/A	N/A	34	Y	M>PBR	U
Sowerby's beaked whale	W. North Atlantic	N/A	N/A	34	Y	M>PBR	U
Risso's dolphin	W. North Atlantic	11,140	111	68			U
Pilot whale (long-finned)	W. North Atlantic	3,537	28	109	Y	M>PBR	U
Pilot whale (short-finned)	W. North Atlantic	457	3.7	109	Y	M>PBR	U
Atlantic white-sided dolphin	W. North Atlantic	12,538	125	127	Y	M>PBR	U
White-beaked dolphin	W. North Atlantic	N/A	N/A	0.0			U
Common dolphin	W. North Atlantic	3,233	32	449	Y	M>PBR	U
Atlantic spotted dolphin	W. North Atlantic	4,885	9.8	31	Y	M>PBR	U
Pantropical spotted dolphin	W. North Atlantic	N/A	N/A	31	Y	M>PBR	U
Striped dolphin	W. North Atlantic	9,165	73	63			U
Spinner dolphin	W. North Atlantic	N/A	N/A	1.0			U
Bottlenose dolphin	Mid-Atlantic offshore	9,195	92	128	Y	M>PBR	U
Bottlenose dolphin	Mid-Atlantic coastal	2,482	25	29	Y	D	S

...to be continued in next table...

[1] N_{MIN} = Minimum population is estimated as the lower 20th percentile of the log-normal distribution of the population estimate, which is equivalent to the lower limit of a 60% two-tailed confidence interval.
[2] PBR = Potential biological removal.
[3] Strategic status: Y = yes, N/A = information is not available and N/D = estimated value has not been determined at this time.
[4] MMPA/ESA status: E = listed as endangered and T = listed as threatened under the Endangered Species Act.
D = listed as depleted under the Marine Mammal Protection Act.
[5] Trend is increasing (I), stable (S), decreasing (D), and unknown (U).

reproductively isolated from the coastal stocks. For example, two bottlenose dolphins previously seen in the South Padre Island, Texas, coastal area were seen in Matagorda Bay, 285 km north, in May 1992 and May 1993. Preliminary analyses of MtDNA using polymerase chain reaction procedures suggested that Matagorda Bay dolphins appear to be a localized population. Over 1,000 individual bottlenose dolphins have been identified in bay and coastal waters near the northeast end of Galveston Island, Texas, but most of these were sighted only once with only 200 individuals reported to use the area over the long term.

Much less is known about the movements of resident bottlenose dolphins in estuaries of the northern Gulf of Mexico. Seasonal differences in bottlenose dolphin abundance in Mississippi Sound suggest seasonal migration; however, the spatial migration patterns are not currently known. It appears probable that some exchange occurs between the Mississippi Sound stock and the coastal stock in this area. Additional information may result in the future combining of these stocks in this area.

Population Size

Population size for all of the stocks except Sarasota Bay, Florida, was estimated from preliminary analyses of line-transect data collected during aerial surveys conducted in September-October 1992 in Texas and Louisiana, in September-October 1993 in Louisiana, Mississippi, Alabama, and the Florida panhandle, and aerial surveys of the west coast of Florida in September-November. Stock size in Sarasota Bay, Florida, was obtained through direct count of known individuals.

Minimum Population Estimate

Minimum population estimates were calculated from the estimates of population size and their associated coefficients of variation (Table 24-1). Where the population size resulted from a direct count of known individuals, the minimum population size was identical to the estimated population size.

Current Population Trend

Population data are insufficient to determine trends for the stocks of bottlenose dolphin. However, three anomalous mortality events occurred among portions of the stocks between 1990 and 1994, and while these events may have resulted in declines in some populations, it is not possible to accurately partition the mortalities between the bay and coastal stocks. Thus the impact of these mortality events on the stocks is not known.

Status of Stock

Bottlenose dolphin PBRs are calculated using a recovery factor of 0.50 because of their unknown status relative to OSP. Estimates of PBR for each stock are given in Table 24-1.

Even though stocks are not listed as threatened or endangered, the occurrence of the three anomalous mortality events is cause for concern. While the effects of the mortality events on stock abundance has not yet been determined, the evidence suggests that bottlenose dolphin stocks in the northern and western coastal portion of the U.S. Gulf of Mexico may have experienced a morbillivirus epidemic in 1993. Seven of 35 live-captured bottlenose dolphins (20%) from Matagorda Bay, Texas, in 1992, tested positive for previous exposure and it is possible that other estuarine resident stocks have been exposed as well.

Limited population monitoring surveys in Mississippi Sound indicated a significantly lower average summer bottlenose dolphin abundance between 1985 and 1993. The apparent decline in summer abundance of bottlenose dolphins in Mississippi Sound is evidence of a possible downward trend in abundance; however, there are insufficient data available with which to conduct a meaningful trend analysis. The relatively high number of bottlenose dolphin deaths which occurred during the recent mortality events suggests that some of these stocks may be physiologically stressed, possibly from nearshore pollution and chemical contamination or other causes. For these reasons, and because the PBR for most of these relatively small stocks would be exceeded with the incidental capture of a single dolphin, each of these stocks is recognized as a strategic stock.

Harbor Porpoise: Gulf of Maine/Bay of Fundy Stock

Stock Definition and Geographic Range

This harbor porpoise stock is found in U.S. and Canadian waters. During the summer (July

to September), harbor porpoise are concentrated in the northern Gulf of Maine-southern Bay of Fundy region, generally in waters less than 150 meters deep. During fall (October to December) and spring (April to June), harbor porpoise are widely dispersed from North Carolina to Maine, though in much lower densities than that seen during the summer. No specific migratory routes to the northern Gulf of Maine/lower Bay of Fundy region have been documented. Animals are seen from the coastline to the middle of the Gulf of Maine (>200 meters deep) in both spring and fall. There is little information about the distribution of harbor porpoise during winter (December to March), although numerous strandings have occurred on beaches from North Carolina to New York. There are two stranding records from Florida.

Four separate populations have been proposed in the western North Atlantic; these being the Gulf of Maine/Bay of Fundy, Gulf of St. Lawrence, Newfoundland and Greenland populations. Presently there is insufficient evidence to accept or reject this hypothesis for the population structure. Results of a workshop held in February 1994 were inconclusive with respect to population structure of harbor porpoise in the western North Atlantic, although it was agreed that animals found in the Gulf of Maine and Bay of Fundy are from the same stock. To resolve the larger scale stock structure question, research is currently being conducted to reanalyze existing genetic data and analyze new samples.

Population Size

To estimate the absolute population size of the harbor porpoises aggregated in the Gulf of Maine/Bay of Fundy region during the summer, two line-transect sighting surveys were conducted, one in 1991, the other in 1992. The abundance estimates were 37,500 (CV = 0.29, 95% CI = 26,700-86,400) and 67,500 (CV = 0.23, 95% CI = 32,900-104,600), respectively. A weighted-average estimate of harbor porpoise abundance was 47,200 (CV = 0.19, 95% CI = 39,500-70,600), where each estimate was weighted by the inverse of its variance. Possible reasons for the inter-annual abundance and distribution differences include inter-annual changes in water temperature and availability of primary prey species which could have affected the distribution of porpoise in the area surveyed.

Minimum Population Estimate

The minimum population estimate calculated for this population is 40,297 porpoises (Table 24-1).

Current Population Trend

Data are insufficient to determine the population trends for this species. Although previous abundance estimates for harbor porpoises in the Gulf of Maine/Bay of Fundy are available from earlier studies, these cannot be used in a trends analysis because they were for selected small regions within the entire known summer range and, in some cases, did not incorporate any estimate of the probability that an animal on the transect track line will be missed.

Status of the Stock

Although there are insufficient data to determine the population trends for this stock, it is classified as strategic because total annual fishery-related mortality and serious injury exceeds an estimated PBR of 403 animals. As a result, NOAA Fisheries has proposed listing the Gulf of Maine harbor porpoise as threatened under the ESA. In Canada, the Cetacean Protection Regulations of 1982, promulgated under the standing Fisheries Act, prohibit the catching or harassment of all species of cetaceans, including the harbor porpoise, although incidental takes of harbor porpoise in gillnets continue to occur in U.S. and Canadian waters.

Gray Seal: Western North Atlantic Stock

Stock Definition and Geographic Range

In the western North Atlantic, there is one stock of gray seals that ranges from New England to Labrador and that is centered in the Gulf of St. Lawrence. This stock is separated by both geography and differences in the breeding season from the eastern Atlantic stock. The western Atlantic stock is distributed and breeds principally in eastern Canadian waters. However, small numbers of animals and pupping females have been observed on several isolated islands along the Maine coast and in Nantucket-Vineyard Sound, Massachusetts.

Table 24-1. (Contd.) Status of Marine Mammal Stocks in the Atlantic Region, including the Gulf of Mexico

Species	Stock Area	N_{MIN}[1]	PBR[2]	Total Annual Mortality	Strategic Status[3]	MMPA/ESA Status[4]	Trend[5]
...continued from previous table...							
Harbor porpoise	Gulf of Maine / Bay of Fundy	40,279	403	1,876	Y	M>PBR	U
Harbor seal	W. North Atlantic	28,810	1729	476			I
Gray seal	N.W. North Atlantic	2,035	122	4.5			I
Harp seal	N.W. North Atlantic	N/A	N/A	0			I
Hooded seal	N.W. North Atlantic	N/A	N/A	0			I
Sperm whale	N. Gulf of Mexico	411	0.8	0	Y	E	U
Bryde's whale	N. Gulf of Mexico	17	0.2	0			U
Cuvier's beaked whale	N. Gulf of Mexico	20	0.2	0			U
Blainsville's beaked whale	N. Gulf of Mexico	N/A	N/A	0			U
Gervais' beaked whale	N. Gulf of Mexico	N/A	N/A	0			U
Bottlenose dolphin	Gulf of Mexico outer continental shelf	43,233	432	5			U
Bottlenose dolphin	Gulf of Mexico shelf & slope	4,530	45	5			U
Bottlenose dolphin	W. Gulf of Mexico coastal	2,938	29	13			U
Bottlenose dolphin	N. Gulf of Mexico coastal	3,518	35	10			U
Bottlenose dolphin	E. Gulf of Mexico coastal	8,963	90	8			U
Bottlenose dolphin	Gulf of Mexico inland waters[6]	N/A	39.7	30	Y	?	U
Atlantic spotted dolphin	N. Gulf of Mexico	2,555	23	1.5			U
Pantropical spotted dolphin	N. Gulf of Mexico	26,510	265	1.5			U
Striped dolphin	N. Gulf of Mexico	3,409	34	0			U
Spinner dolphin	N. Gulf of Mexico	4,465	45	0			U
Rough-toothed dolphin	N. Gulf of Mexico	660	6.6	0			U
Clymene dolphin	N. Gulf of Mexico	4,120	41	0			U
Fraser's dolphin	N. Gulf of Mexico	66	0.7	0			U

...to be continued in next table...

[1] N_{MIN} = Minimum population is estimated as the lower 20th percentile of the log-normal distribution of the population estimate, which is equivalent to the lower limit of a 60% two-tailed confidence interval.
[2] PBR = Potential biological removal.
[3] Strategic status: Y = yes, N/A = information is not available and N/D = estimated value has not been determined at this time.
[4] MMPA/ESA status: E = listed as endangered and T = listed as threatened under the Endangered Species Act.
D = listed as depleted under the Marine Mammal Protection Act.
[5] Trend is increasing (I), stable (S), decreasing (D), and unknown (U).
[6] Represents at least 33 individually recognized stocks of bottlenose dolphin in U.S. Gulf of Mexico bays, sounds, and other estuaries.

Population Size

A winter breeding colony on Muskeget Island, west of Nantucket Island, may provide some measure of gray seal population trends and the rate of expansion of their distribution. During the 1980s, as the gray seal population and range expanded in eastern Canada, sightings in New England increased. In 1988, 5 pups were born at Muskeget. The number of pups increased to 12 in 1992, 30 in 1993, and 59 in 1994. Maximum counts obtained during the spring molt did not exceed 13 in any year during the 1970s, but rose to 61 in 1984, 192 in 1988, 503 in 1992, and 1,549 in 1993. Aerial surveys in April and May of 1994 recorded a peak count of 2,035 gray seals for Muskeget Island (Nantucket) and Monomoy (Cape Cod) combined.

While estimates of the total western Atlantic population are not available, pup production on Sable Island, Nova Scotia, has been about 13% per year since 1962. The 1986 population estimate for individuals that are one year old and older was between 100,000 and 130,000 animals. The 1993 estimate (Sable Island and Gulf of St. Lawrence stocks) is 143,000 animals. The population in waters off Maine has increased from about 30 in the early-1980s to 500 to 1,000 animals in 1993.

Gray seals, like harbor seals, were hunted for bounty in New England waters until the late-1960s. Researchers and fishery observers have documented incidental mortality in several fisheries in recent years, particularly within the Gulf of Maine. An unknown level of mortality also occurs in the mariculture industry (i.e., salmon farming), and from deliberate shooting. An unknown number of gray seals have been taken in Newfoundland and Labrador, Gulf of St. Lawrence, and Bay of Fundy groundfish gillnets, Atlantic Canada and Greenland salmon gillnets, Atlantic Canada cod traps, and in Bay of Fundy herring weirs. In addition to incidental catches, some mortalities (e.g., seals trapped in herring weirs) were the result of direct shooting, and there were culls during the 1970s and early-1980s on Sable Island of about 1,700 animals annually. Estimated average annual fishery-related mortality and serious injury to this stock during 1990-93 attributable to U.S. fisheries was 4.5 gray seals (CV = 2.00).

Minimum Population Size

The minimum population estimate based on uncorrected total counts is 2,035 gray seals.

Current Population Size

Gray seal abundance is likely increasing for waters of the eastern U.S. EEZ, but the actual trend is unknown. In Canadian waters, the population has been increasing for several decades. Approximately 57% of the northwest Atlantic population is from the Sable Island stock.

Status of Stock

Potential biological removal (PBR) was specified as the product of minimum population size (2,035), one-half the maximum productivity rate (0.06), and a recovery factor of 1.0, to give a PBR for this stock of 122 gray seals.

The status of the gray seal population, relative to OSP, in U.S. and Canadian Atlantic coast waters is unknown. The species is not listed as threatened nor endangered under the ESA. Recent information indicate that this population is increasing. In New England waters, both the number of pupping sites and pup production is increasing. In Canada they are protected from harassment and intentional killing under the Marine Mammal Regulations, although some aquaculture operators have been authorized to shoot nuisance animals to protect their facilities. The estimated annual level of human-caused mortality and serious injury in the U.S. Atlantic EEZ does not exceed PBR; therefore, this stock is not a strategic stock.

North Atlantic Right Whale: Western North Atlantic Stock

Stock Definition and Geographic Range

Individual right whales in this population range from wintering and calving grounds in coastal waters of the southeastern United States to summer feeding, nursery, and mating grounds in New England waters and northward to the Bay of Fundy and the Scotian Shelf. Long-distance movements as far north as Newfoundland, the Labrador Basin, and southeast of Greenland, have been reported and suggest an extended range for at least some individuals and perhaps habitat areas not presently well described. Likewise, while a calving and wintering ground is described for coastal waters of the southeastern U.S., 85% of the population is

unaccounted for during the winter season, and sightings from the Gulf of Mexico suggest that the range of this species may be more extensive than previously believed.

Research to date suggests five major habitats or congregation areas for western North Atlantic right whales: southeastern United States coastal waters, Great South Channel, Cape Cod Bay, Bay of Fundy, and Scotian Shelf. However, the results from satellite tagging studies suggest that movements within and between habitats and within regions may be more extensive than previously thought. When compared to the results of satellite tagged animals, sightings of individuals separated by perhaps two weeks cannot be assumed to indicate a stationary or resident animal. Rather, movement data have shown rather lengthy and somewhat distant excursions within a few weeks time within a season. These findings cast new light on the extent of movements and habitat use by right whales, and raise new questions about the purpose or strategies for such excursions.

New England waters are a primary feeding habitat for the right whale, which appears to feed primarily on calanoid copepods in this area. These dense zooplankton patches are likely a primary characteristic of the spring, summer, and fall right whale habitat. During the peak feeding season in Cape Cod and Massachusetts Bays, the acceptable surface copepod resource is limited to perhaps 3% of the region. While feeding in the coastal waters off Massachusetts has been better studied, feeding by right whales have been observed elsewhere over Georges Bank, in the Gulf of Maine, in the Bay of Fundy, and over the Scotian Shelf. The characteristics of acceptable prey distribution in these areas is not as well known as off Massachusetts. New England waters also serve as a nursery for calves and, in some cases, for mating.

Genetic analyses of tissue samples is providing insights to stock definition. It has been suggested that western North Atlantic right whales probably represent a single breeding population that may be based on three matrilines. Genetics also suggests that, in addition to the Bay of Fundy, there exists an additional and undescribed summer nursery area utilized by approximately one-third of the population. As described above, a related question is where individuals other than calving females and a few juveniles overwinter. One or more major wintering and summering grounds have yet to be described for this population.

Population Size

Based on a census of individual whales identified using photo-identification techniques, the western North Atlantic population size was estimated to be 295 individuals in 1992.

Minimum Population Size

It is assumed that the census of identified whales in 1992 represents a minimum population size estimate (295 individuals).

Current Population Size

The size of this population may have been as low as 50 or fewer animals at the turn of the century compared to an estimated 295 presently, suggesting that the stock is showing signs of slow recovery.

Status of Stock

Potential biological removal was specified as the product of minimum population size (295), one-half the maximum productivity rate (0.02), and a "recovery" factor of 0.1 because this species is listed as endangered under the ESA. Potential biological removals for the northern right whale is 0.4 whales.

Table 24-1. (Contd.) Status of Marine Mammal Stocks in the Atlantic Region, including the Gulf of Mexico

Species	Stock Area	N_{MIN}[1]	PBR[2]	Total Annual Mortality	Strategic Status[3]	MMPA/ESA Status[4]	Trend[5]
...continued from previous table...							
Killer whale	N. Gulf of Mexico	197	2	0			U
False killer whale	N. Gulf of Mexico	236	2.4	0			U
Pygmy killer whale	N. Gulf of Mexico	285	2.8	0			U
Dwarf sperm whale	N. Gulf of Mexico	N/A	N/A	0	Y	?	U
Pygmy sperm whale	N. Gulf of Mexico	N/A	N/A	0	Y	?	U
Melon-headed whale	N. Gulf of Mexico	2,888	29	0			U
Risso's dolphin	N. Gulf of Mexico	2,199	22	19			U
Pilot whale (short-finned)	N. Gulf of Mexico	186	1.9	0.3			U
West Indian manatee	Florida				Y	E	D
West Indian manatee	Antillean				Y	E	D

[1] N_{MIN} = Minimum population is estimated as the lower 20th percentile of the log-normal distribution of the population estimate, which is equivalent to the lower limit of a 60% two-tailed confidence interval.
[2] PBR = Potential biological removal.
[3] Strategic status: Y = yes, N/A = information is not available and N/D = estimated value has not been determined at this time.
[4] MMPA/ESA status: E = listed as endangered and T = listed as threatened under the Endangered Species Act.
D = listed as depleted under the Marine Mammal Protection Act.
[5] Trend is increasing (I), stable (S), decreasing (D), and unknown (U).

Approximately one-third of all right whale mortality is caused by human activities. Further, the small population size and low annual reproductive rate suggest that human sources of mortality may have a greater effect relative to population growth rates than for other whales. The principal factors believed to be retarding growth and, perhaps recovery of the population, are ship strikes and net entanglement. Marks or scars from entanglement with fishing gear were reported from 57% of living right whales, and 7% had major wounds probably due to collisions with ship propellers. Of the 25 mortalities recorded, five (20%) could be attributed to ship collisions, and three (12%) were the result of entanglements. Young animals, ages 0-4 years, are apparently the most impacted portion of the population. In this age group, 20-30% of mortality is due to ship strikes.

The size of this stock is considered to be low relative to its OSP and this species is listed as endangered under the ESA. A Recovery Plan has been published and is in effect, though not completely implemented. The total level of human-caused mortality and serious injury is unknown, but reported human-caused mortality and serious injury has exceeded two right whales per year since 1990. This rate exceeds PBR and is significant because of the critically low population size and the low population growth rate. This is a strategic stock. ❑

Sea Turtles

Introduction

Sea turtles are highly migratory and found throughout the world's oceans. Six species are found in the United States: loggerhead, Kemp's ridley, green, leatherback, hawksbill, and olive ridley turtles. On the west coast, the green turtle and hawksbill are most abundant in Hawaiian waters; while the loggerhead, leatherback, and olive ridley turtles are most commonly reported along the continental Pacific coast. All five species are also found in the Atlantic Ocean, but the olive ridley rarely enters U.S. waters.

All six species of sea turtles found in the U.S. (8 species worldwide) are currently listed either as endangered or threatened under the ESA. The Kemp's ridley, hawksbill, and leatherback are listed as endangered throughout their ranges. The loggerhead and olive ridley are listed as threatened, as is the green turtle, except the Florida nesting population which is listed as endangered. The authority to protect and conserve sea turtles in the marine environment is vested to NOAA Fisheries, while the U.S. Fish and Wildlife Service maintains authority for sea turtles on land.

Species and Status

Atlantic Region

Historical data on sea turtle numbers are limited. In addition, the length of time that data have been collected has been short when compared with the long life and low reproductive rate of all turtle species. The estimated number of female loggerheads nesting annually in the southeastern United States is about 20,000-28,000. Most nest along Florida's east coast where nest numbers have been stable for 5 years (Fig. 25-1). Loggerhead turtles nesting has not shown any decline over the past 18 years. Only about 700-800 female Kemp's ridley turtles nest annually along a limited portion of Mexico's Gulf coast (Fig. 25-1). In 1947, on a single day, 40,000 females were seen nesting on one beach alone. This dramatic decline in the Kemp's ridley is probably indicative of similar population trends for other sea turtles, though the magnitude and period of their declines may be different.

Historically, green turtles were taken for commercial use along the Florida and Texas coasts. Currently, 400-500 green turtles nest annually along the Florida coast. Under protection, green and Kemp's ridley turtles in the Gulf of Mexico may have begun increasing. There is no historical estimate of the numbers of hawksbill or leatherback turtles nesting on U.S. Caribbean beaches. The hawksbill has been heavily exploited, and continued trade of products from this species suggests that further declines are possible. The abundance trend of the leatherback turtle in U.S. waters is unknown.

Pacific Region

Although there is one record of the olive ridley turtle nesting in Hawaii, most reproduc-

Table 25-1. Sea Turtles

Area / Species	Historic Level	Current Level[1]	Trend	Status in U.S.
Atlantic Region				
Loggerhead	Unknown	20,000 - 28,000[2]	Stable[6]	T[3]
Green	Unknown	400-500[2]	Increasing	T,E[4]
Kemp's ridley	40,000	700-800[5]	Stable[6]	E
Leatherback	Unknown	Unknown	Unknown	E
Hawksbill	Unknown	Unknown	Declining	E
Pacific Region				
Loggerhead	Unknown	Unknown	Declining	E
Green	10,000	500[7]	Increasing[8]	T
Olive ridley	Unknown	Unknown	Unknown	T
Leatherback	Unknown	Unknown	Unknown	E
Hawksbill	Unknown	>75[9]	Unknown	E

[1] Estimates of sea turtle abundance as indicated by number of female sea turtles nesting on U.S. beaches.
[2] Using 2.5 nests per female.
[3] Listed as threatened under the Endangered Species Act.
[4] Listed as endangered in Florida; threatened in the U.S. Atlantic and Pacific.
[5] Using 1.5 nests per female. Kemp's ridley turtles nest only on one Mexican beach.
[6] Stable, but critically low.
[7] Historical level for Hawaii only. Estimated 1995 total adult female popultion is 1,500 in Hawaii; 100-300 in American Samoa; current level in Guam is unknown.
[8] Trend in Hawaii only, monitored at French Frigate Shoals; however, great concern exists over increasing frequency of fibropapilloma disease in all Hawaiian green turtles.
[9] Estimated total adult population in Hawaii; average number of female hawksbills nesting annually in Hawaii is about 15. Current abundance in Guam and American Samoa is unknown.

tive colonies are in continental coastal areas and olive ridleys are nearly unknown around the western Pacific islands. The loggerhead turtle has been recorded, but uncommon, from the Mariana Islands, Samoa, and Hawaii. The species is primarily associated with continents and boundary currents rather than islands. Loggerheads do not nest in the western Pacific region. The leatherback turtle is a pelagic species that probably occurs near all U.S. Pacific islands, although nesting in none except the Solomon Islands and Irian Jaya. The hawksbill turtle is present at all western Pacific U.S. islands. About 75 adult hawksbills were estimated to be present in Hawaii in 1993, with only 15 nesting females. The number of hawksbills present in Samoa and Guam is unknown but nesting has been observed at Rose Atoll and the Manua Islands.

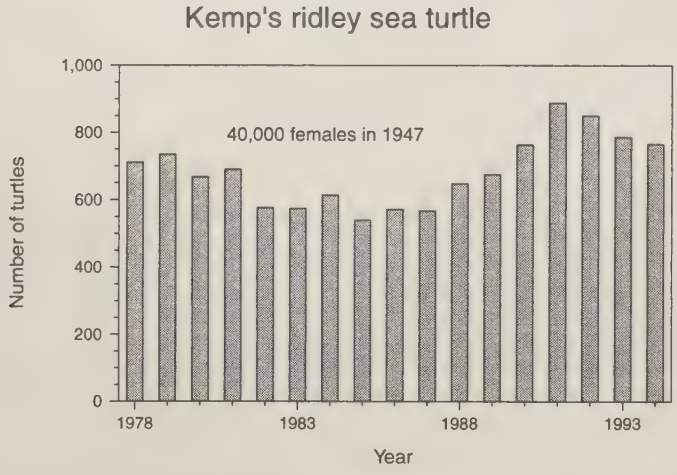


Fig. 25-1. Number of nesting Kemp's ridley sea turtles.

The status of leatherback, hawksbill, and loggerhead turtles throughout the Pacific is unknown, but mortality of leatherbacks from fishery bycatch and continued exploitation of hawksbills for their shells in areas outside of the United States makes them a special conservation concern.

The green turtle is the most abundant turtle in the western Pacific region. It is probably present at all U.S. islands. The historic level of its population was estimated to have been about 10,000. In 1995 about 1,500 adult females were estimated to exist in Hawaii, with about 500 nesting during the year at French Frigate Shoals in the NWHI, where >90% of the nesting in Hawaii occurs. An additional 100-300 green turtles were estimated to be in American Samoa, nesting primarily at Rose Atoll. The numbers at Guam were unknown, with only sporadic nesting recorded. The population at French Frigate Shoals is thought to be increasing.

Issues

Bycatch and Fisheries Interactions

Sea turtles are threatened by multiple factors, most of which are human-related. A principal concern is incidental capture in commercial fisheries. Trawls, longline, and gillnet fisheries pose the greatest threats. Prior to the implementation of Turtle Excluder Device (TED) regulations, the National Academy of Science estimated that a maximum of 44,000 turtles, mostly loggerheads and Kemp's ridleys, were killed annually in the Gulf of Mexico and southeast U.S. Atlantic shrimp fishery. While TED use is mandated for the shrimp fishery and most of the summer flounder trawl fishery, recent mortality events indicate that significant mortality is still occurring in some areas as a result of these trawl fisheries. Turtles are also taken and killed in pelagic longline and gillnet fisheries. Of particular concern are the gillnet fisheries for coastal species, including sharks.

Propeller strikes and vessel collisions also pose significant threats to some sea turtles, especially in areas of high human population, where recreational boat traffic is heavy and coastal ports are active.

Habitat Concerns

Coastal development can reduce nesting, egg incubation, and foraging habitats for sea turtles. Rookeries of the southeastern U.S. are essential to the recovery and survival of sea turtles. Many nesting beaches have already been significantly degraded or destroyed. Nesting habitat is threatened by rigid shoreline protection or "coastal armoring" such as sea walls and sandbag installations. Additionally, nesting habitat is negatively impacted by beach nourishment projects that are improperly timed to occur during the nesting season or that use poor quality fill material. Artificial beach-front lighting, increased human activity, and beach driving also threaten species recovery. Thus, conservation and long-term protection of sea turtle nesting habitat are high management priorities.

Marine Debris

Ingestion of some marine debris can be a serious threat to wildlife. Sea turtles mistake clear plastic bags for jellyfish, one of their favorite meals. Floating tar balls and plastics are occasionally eaten. Ingested debris damages the digestive tract, causes starvation by blocking food, may be toxic, and in general is a serious source of mortality to the animals.

Disease

A disease, known as green turtle fibropapilloma (GTFP), is affecting a significant number of green turtles, most notably in Florida and Hawaii. The tumors from GTFP infection, which occur primarily on the skin and eyes, can be fatal. The cause of the disease remains unknown. In 1991, 31% of Kaneohe Bay's green turtles in Hawaii were afflicted and in 1989-90, 77-85% of the stranded turtles on Maui had fibropapillomas. Research to determine the cause of this disease is a high priority because the Hawaiian population was among the few increasing stocks prior to the disease's increase.

Progress

Substantial progress has been made to eliminate incidental capture of sea turtles in the high seas driftnet fisheries in the open ocean. A United Nations-sponsored moratorium on large-scale driftnet fishing went into effect on 1 January 1993 which eliminated high seas driftnet fishing in the Pacific. The United States played a key role in passing the moratorium.

In the Hawaii pelagic longline fishery for tuna and swordfish, the incidental catch of turtles is being closely monitored through a compulsory logbook program established in November 1990. A mandatory scientific observer program was also implemented in February 1994, to collect more detailed data required to verify logbook reports, derive accurate estimates of turtle take rates and assess turtle mortality. During 1993, a workshop was held to formulate research techniques to determine hooking and entanglement mortality of turtles incidentally caught by longline. Another workshop was held in 1995 to identify ways to reduce or mitigate the impacts of incidental capture and handling of turtles during longline retrieval.

Significant progress is also being made in the monitoring of Hawaiian green turtles. In 1992, a 5-year series of saturation surveys was completed at East Island, French Frigate Shoals, the principal location of Hawaiian green turtle nesting, by NOAA Fisheries and the USFWS. Based on these surveys, rigorous quantitative methods have been developed for annual nesting surveys at East Island. Progress is also being made in monitoring juvenile and subadult Hawaiian green turtles in their nearshore habitat. A vigorous research program is underway to study the origins and effects of fibropapilloma tumor disease in the Hawaiian green turtle population; progress has been made in developing information relevant to potential etiologies involving cardiovascular parasites, viruses, and environmental pollutants. A similar disease situation exists among green turtles in Florida and the Caribbean.

Two joint NOAA Fisheries/USFWS sea turtle recovery plans, one for the U.S. Pacific and the other for the U.S. Atlantic, have been developed. These plans prioritize turtle research requirements and delineate reasonable actions which are believed to be required to recover and/or protect the species.

A major factor affecting the recovery of turtle populations is the mitigation of commercial fishing-sea turtle interactions. The incidental capture of sea turtles in various commercial fisheries has been studied and summarized and was the focal point of a meeting at the recent 13th Annual Sea Turtle Symposium. Recent legislation has allowed NOAA Fisheries to use observers in selected fisheries to document the occurrence of incidental turtle captures. Also, several new TED models have been recently tested and approved for commercial use, and research continues on the development of a new TED design which would accommodate small inshore turtles.

Considerable progress has been made on inshore juvenile habitat research and remote sensing. NOAA research projects have been started on juvenile ridleys and greens in the Cedar Keys and Biscayne Bay, Florida, and in the northwestern Gulf of Mexico. Additionally, a comprehensive research project concerning the incidence, etiology, and epidemiology of fibropapilloma tumor disease in Atlantic green turtles has been started. Concern is growing that this disease may seriously affect the recovery of world-wide green turtle populations. ❑

Part 3

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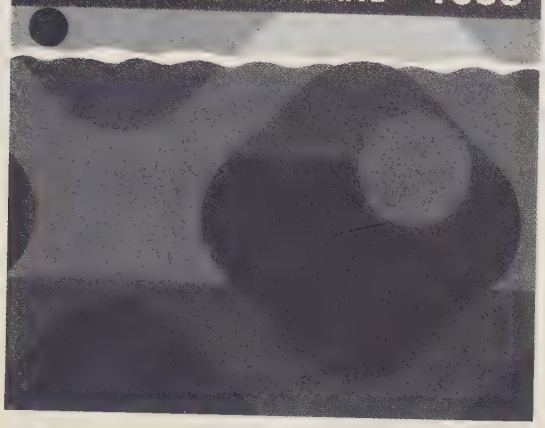

Appendices

Appendix 1

Acknowledgments

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Figure 1. (U.S. EEZ) was adapted with permission from a map by Mary Beath in "A Nation of Oceans," published by the Center for Marine Conservation. ❑

Appendix 2

Fishery Management Councils and Fishery Management Plans

New England Fishery Management Council

Suntaug Office Park
5 Broadway (Rt. 1)
Saugus, MA 01906
(617) 231-0422

Jurisdiction
Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut

Fishery Management Plans
- American Lobster FMP
- FMP for the Northeast Multispecies Fishery
- FMP for Atlantic Sea Scallops
- Atlantic Salmon FMP

Mid-Atlantic Fishery Management Council

Federal Building, Room 2115
300 S. New Street
Dover, DE 19904
(302) 674-2331

Jurisdiction
New York, New Jersey, Delaware, Virginia, Pennsylvania, Maryland

Fishery Management Plans
- FMP for Atlantic Mackerel, Squid, and Butterfish Fisheries
- FMP for Atlantic Surf Clam and Ocean Quahog Fisheries
- FMP for Atlantic Bluefish
- FMP for Summer Flounder

South Atlantic Fishery Management Council

One Southpark Circle, Suite 306
Charleston, SC 29407
(803) 571-4366

Jurisdiction
North Carolina, South Carolina, Georgia, east coast of Florida

Fishery Management Plans
- FMP for Spiny Lobster in the Gulf of Mexico and the South Atlantic
- FMP for the Snapper-Grouper Fishery of the South Atlantic Region
- Atlantic Coast Red Drum FMP
- FMP for the Coastal Migratory Pelagic Resources
- FMP for Coral, Coral Reefs, and Live/Hard Bottom Habitats of the South Atlantic Region
- FMP for the Shrimp Fishery of the South Atlantic Region

Gulf of Mexico Fishery Management Council

Lincoln Center, Suite 331
5401 W. Kennedy Boulevard
Tampa, FL 33609
(813) 228-2815

Jurisdiction
Texas, Louisiana, Mississippi, Alabama, west coast of Florida

Fishery Management Plans
- FMP for the Spiny Lobster Fishery of the Gulf of Mexico and South Atlantic
- FMP for Coastal Migratory Pelagic Resources of the Gulf of Mexico and South Atlantic
- FMP for Coral and Coral Reefs in the Gulf of Mexico
- FMP for the Stone Crab Fishery of the Gulf of Mexico
- FMP for the Shrimp Fishery of the Gulf of Mexico
- FMP for the Reef Fish Resources of the Gulf of Mexico
- FMP for the Red Drum Fishery of the Gulf of Mexico

Caribbean Fishery Management Council

268 Munoz Rivera Avenue, Suite 1108
San Juan, PR 00918
(809) 766-5926

Jurisdiction
Virgin Islands, Commonwealth of Puerto Rico

Fishery Management Plans
- FMP for the Spiny Lobster Fishery of Puerto Rico and the U.S. Virgin Islands
- FMP for the Shallow Water Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands
- FMP for Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the U.S. Virgin Islands

Pacific Fishery Management Council

2130 SW 5th Avenue, Suite 224
Portland, OR 97201
(503) 326-6352

Jurisdiction
California, Washington, Oregon, Idaho

Fishery Management Plans
- FMP for the Groundfish Fishery off Washington, Oregon, and California
- Northern Anchovy FMP
- FMP for Commercial and Recreational Salmon Fisheries off the Coasts of Wash ington, Oregon, and California

Western Pacific Fishery Management Council

1164 Bishop Street, Suite 1405
Honolulu, HI 96813
(808) 522-8220

Jurisdiction
Hawaii, American Samoa, Guam, Northern Marianas Islands

Fishery Management Plans
- FMP for the Crustacean Fishery of the Western Pacific Region
- FMP for the Precious Corals Fisheries of the Western Pacific Region
- FMP for the Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region
- FMP for the Pelagic Fisheries of the Western Pacific Region

North Pacific Fishery Management Council

605 W. 4th Avenue, Room 306
Anchorage, AK 99501-2252
(907) 271-2809

Jurisdiction
Alaska

Fishery Management Plans
- FMP for Groundfish of the Gulf of Alaska
- FMP for the Groundfish Fishery of the Bering Sea and Aleutian Islands Area
- FMP for the High Seas Salmon Fishery off the Coast of Alaska East of 175 Degrees East Longitude
- Bering Sea/Aleutian Islands King and Tanner Crab FMP
- FMP for the Scallop Fishery off Alaska

Secretarial Plans

- FMP for Atlantic Swordfish
- FMP for Atlantic Billfishes
- FMP for Sharks of the Atlantic Ocean

Appendix 3

Principal Facilities of NOAA Fisheries

Office of the Assistant Administrator for Fisheries

National Marine Fisheries Service, NOAA
1315 East-West Highway
Silver Spring, MD 20910
(301) 713-2239

Regional Offices and Fishery Science Centers

Northeast Regional Office
One Blackburn Drive
Gloucester, MA 01930
(508) 281-9300

Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543
(508) 548-5123

Woods Hole Laboratory
Woods Hole, MA
(508) 548-5123

Narragansett Laboratory
Narragansett, RI
(401) 782-3200

Milford Laboratory
Milford, CT
(203) 783-4200

James J. Howard Marine Sciences Laboratory
Highlands, NJ
(908) 872-3000

National Systematics Laboratory
Washington, DC
(202) 357-2550

Southeast Regional Office
9721 Executive Center Drive North
St. Petersburg, FL 33702
(813) 570-5301

Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, FL 33149
(305) 361-5761

Miami Laboratory
Miami, FL
(305) 361-4284

Mississippi Laboratories
Pascagoula, MS
(601) 762-4591

Panama City Laboratory
Panama City, FL
(904) 234-6541

Galveston Laboratory
Galveston, TX
(409) 766-3500

Charleston Laboratory
Charleston, SC
(803) 762-8511

Beaufort Laboratory
Beaufort, NC
(919) 728-3595

Oxford Cooperative Laboratory
Oxford, MD
(410) 226-5193

Regional Offices and Fishery Science Centers (continued)

Southwest Regional Office
501 W. Ocean Blvd., Suite 4200
Long Beach, CA 90802
(310) 980-4000

Southwest Fisheries Science Center
P.O. Box 271
8604 La Jolla Shores Dr.
La Jolla, CA 92038
(619) 546-7000

La Jolla Laboratory
La Jolla, CA
(619) 546-7000

Honolulu Laboratory
Honolulu, HI
(808) 943-1221

Tiburon Laboratory
Tiburon, CA
(415) 435-3149

Pacific Fisheries Environmental Group
Pacific Grove, CA
(408) 648-8515

Northwest Regional Office
7600 Sand Point Way N.E.
BIN C15700, Building 1
Seattle, WA 98115
(206) 526-6150

Northwest Fisheries Science Center
2725 Montlake Blvd. E.
Seattle, WA 98112
(206) 860-3200

Hatfield Marine Sciences Laboratory
Newport, OR
(503) 867-0100

Kodiak Investigations–Utilization
Kodiak, AK
(907) 486-1518

Alaska Regional Office
709 West 9th Street
Juneau, AK 99801
(907) 586-7221

Alaska Fisheries Science Center
7600 Sand Point Way N.E.
BIN C15700, Building 4
Seattle, WA 98115
(206) 526-4000

Seattle Laboratory
Seattle, WA
(206) 526-4000

National Marine Mammal Laboratory
Seattle, WA
(206) 526-4045

Auke Bay Laboratory
Auke Bay, AK
(907) 789-6000

Kodiak Laboratory
Kodiak, AK
(907) 487-5961

Appendix 4

Stock Assessment Principles and Terms

Much of the information in this document comes from the scientific analysis of fisheries data to develop stock assessments. **Stock assessment** includes an estimation of the amount or abundance of the resource, an estimation of the rate at which it is being removed due to harvesting and other causes, and one or more reference levels of harvesting rate and/or abundance at which the stock can maintain itself in the long term. Such assessments often contain short-term (1-5 years, typically) projections or prognoses for the stock under a number of different fishing and management scenarios. This information on resource status is used by managers to determine what actions are needed to promote the best use of our living marine resources.

Stock assessment analyses rely on various sources of information to estimate resource abundance and population trends. The principal information comes from the commercial and recreational fishery themselves. For example, the amount of fish caught, the individual sizes of the fish and their biological characteristics (e.g., age, maturity, sex), and the ratio of fish caught to the time spent fishing (catch per unit of effort) are basic data for stock assessments. In addition, NOAA Fisheries conducts resource surveys with specialized research vessels or chartered fishing vessels. These surveys, often conducted in cooperation with state marine resource agencies, universities, international scientific organizations, and fisheries agencies of other nations, produce estimates of resource abundance.

Research surveys are conducted differently from commercial fishing. While commercial operations seek out the greatest aggregations of fish and concentrate on them to obtain the largest or most valuable catch, research surveys fish in a standardized manner over a wide range of locations within the waters inhabited by the stocks to provide unbiased population abundance and distribution index year after year. The survey results are then used in conjunction with commercial and recreational catch data to assess the resource base. The final critical data comes from studies on the basic biology of the animals themselves. Understanding the natural history of the harvested species and the other species with which they interact is crucial to understanding dynamics of the resources.

Fish abundance or population size can be expressed as either the number of fish or the total fish weight (or "biomass"). Increases in the amount of fish are determined by body growth of individual fish in the population, and the addition or **recruitment** of new generations of young fish (i.e., "recruits"). Those gains must then be balanced against the proportion of the population removed by harvesting (called **fishing mortality, F**) and other losses due, for example, to predation, starvation, or disease (called **natural mortality, M**). In stock assessment work, removals of fish from the population are commonly expressed in terms of rates within a time period. The **fishing mortality rate** is a function of **fishing effort**, which includes the amount, type, and effectiveness of fishing gear and the time spent fishing.

Surplus production (or just "production") is the total weight of fish that can be removed by fishing without changing the size of the population. It is calculated as the sum of the growth in weight of individuals in a population, plus the addition of biomass from new recruits, minus the biomass of animals lost to natural mortality.

The **production rate** is expressed as a proportion of the population size or biomass. The production rate is highly variable owing to environmental fluctuations, predation and other biological interactions with other populations. On average, production decreases at low and high population sizes. Thus, surplus production tends to be low at the extremes of population size (i.e. where biomass or production rate is low). It is more likely to be high at some intermediate level of population biomass. But, on average, biomass decreases as the amount of fishing effort increases. This means there is a relationship between average production and fishing effort. This relationship is known as the **production function**.

Production functions are the basis for certain important concepts used in this report: **Long-term Potential Yield** (LTPY), **Current**

Potential Yield (CPY), and **Recent Average Yield** (RAY). In addition, the term **Stock Level** is employed as a biological reference for determining resource status relative to the stock level which would on average support the LTPY. Recent Average Yield also is reported in order to allow comparison of the current situation to long-term potential.

Long Term Potential Yield (LTPY)

LTPY is the maximum long-term average yield that can be achieved through conscientious stewardship, by controlling **F** through regulating fishing effort or total catch. LTPY is a reference point for judging the potential of the resource. However, it is not necessarily the goal of management to always take the maximum yield. Other factors influence the choice of a management objective, such as socioeconomic considerations or conservation and ecosystem concerns for other resources indirectly affected by fishery harvests. LTPY may be controversial to estimate. Nevertheless, NOAA scientists have used their best professional judgment to provide these figures as a gauge of long-term production potential whenever possible.

Current Potential Yield (CPY)

CPY, the current potential catch that can be safely taken, depends on the current abundance of fish and population dynamics of the stock. It is usually estimated by applying F associated with LTPY (e.g., target fishing effort) to the current population size. This yield may be either greater than or less than LTPY. CPY is the amount of catch that will maintain the present population level (biomass) or, for overutilized stocks, stimulate a trend toward recovery to a population size that will produce the LTPY. For stocks at high biomass levels, the CPY may be larger than the LTPY. In this circumstance a large fishery harvest would not be sustainable in the long run, but it would bring the stock down to the level supporting LTPY.

Recent Average Yield (RAY)

RAY is equivalent to recent average catch. Unless designated otherwise, RAY is the reported fishery landings averaged for the most recent three-year period, 1992-94.

Stock Level Relative to LTPY

To further clarify resource status, stock level (i.e., abundance) in the most recent year is compared with the level of abundance which on average would support the LTPY harvest. This is expressed as being **Below, Near, Above or Unknown** relative to the LTPY stock level. In some cases, heavy fishing in the past reduced a stock to a low abundance, and even if the stock currently is harvested only lightly, it may take many years for it to rebuild.

Status of Utilization

In this report, a resource is classified as **underutilized, fully utilized, overutilized, or unknown** as a qualitative measure of the level of use. This is derived by comparing the present levels of fishing effort and stock abundance to those levels necessary to achieve LTPY.

It may differ from some evaluation of a fishery required under the MFCMA and the accompanying guidelines for preparations of Fishery Management Plans. Each management plan contains a specific definition of overfishing which is used for management purposes. The MFCMA national standards require management plans to be designed to give the highest continuing yield possible as modified by social and economic factors. In practice, this means each management plan may have different goals and hence different definitions of overfishing. As this report is intended to provide a broad overview across all fisheries, we use the more comparable measures of fishery conditions described below. These characterizations with respect to recent stock levels and fishing effort are in no way intended to supplant the specific definitions used to trigger management actions contained in fishery management plans.

A fishery resource is defined as **fully utilized** when the amount of fishing effort used is about equal to the amount needed to achieve LTPY and where the resource is near its LTPY stock level. For fully utilized fisheries, the RAY and CPY are usually about equal. In most cases, LTPY and CPY are also about equal, but they may differ as a result of production variability. A fishery resource is considered **overutilized** when more fishing effort is employed than is necessary to achieve LTPY. When RAY is greater than CPY, and CPY is less than LTPY, overutilization is indicated. If stock abundance is near the level that on average produces LTPY,

RAY may be greater than LTPY for an overutilized stock, implying that recent landings levels cannot be sustained. If stock abundance is below the level associated with LTPY, RAY will likely be less than LTPY.

Additionally, it is possible for RAY, CPY, and LTPY to be about equal while the fishery resource is overutilized. This occurs when reducing fishing effort would have little effect on the amount of catch realized. In such cases, overutilization may not have an apparent adverse effect on production, but it further reduces the size of the population, it wastes effort and economic resources, and imposes other deleterious consequences (e.g., excessive bycatch, gear interactions).

A fishery resource is classified as **underutilized** when more fishing effort is required to achieve LTPY. This situation is generally indicated when RAY is less than CPY and CPY is greater than LTPY while stock level is above the reference level that on average produces LTPY. But there may be exceptions. For example, RAY may be held below CPY and LTPY by management to compensate for uncertainty in population estimates and ecosystem considerations.

These are the major factors NOAA Fisheries considers for determining the status of resource utilization for this report, but they may not always give a complete picture. In cases where knowledge about the stock is incomplete or the classification of a fishery's status is based on the best scientific judgment of the NOAA scientists that conducts research on the stock in question.

For many stocks, LTPY or CPY may be unknown. For the purpose of reporting total LTPY and CPY across resources within the various fishery units and for the Nation as a whole, if CPY were unknown RAY was substituted when calculating a unit, regional, or national total CPY. If LTPY were unknown CPY was substituted, or, failing that, RAY was substituted in calculating totals.

In many of the fishery units, a dollar figure is given for the ex-vessel revenue generated by the commercial fishery on a given stock or group of stocks. **Ex-vessel revenue** is defined as the quantity of fish landed by commercial fishermen multiplied by the average price received by them at the first point of sale. As such, ex-vessel revenue captures the immediate value of the commercial harvest, but does not reflect multiplier effects of subsequent revenues generated by seafood processors, distributors, and retailers.

The estimate of "economic value" often takes both recreational and commercial catches and multiplies them by an average price to arrive at a baseline measure of economic worth among various user groups. It may underestimate those fisheries where there is a large recreational component. Nevertheless, the value serves as a useful gauge of relative potential revenues generated over many disparate stocks, fisheries, and regions.

Marine Mammal and Sea Turtle Assessments

The same scientific principles apply to the population dynamics of these protected species, but the terminology of underutilized, fully utilized, and overutilized does not apply. Instead, marine mammals are referred to as **Depleted** when their population size is below the level of **maximum net production**. This is often referred to as their "**optimum sustainable population level**."

The MMPA defines OSP to mean "with respect to any population stock, the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element." For operational purposes, NOAA Fisheries and the USFWS have interpreted this definition to mean "a population size falling within a range from the population level of a given species or stock which is the largest supportable within the ecosystem to the population level that results in maximum net productivity (MNP)." Maximum net productivity is defined as "the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less loses due to natural mortality."

Protected marine mammals and turtles may also be classified as **threatened** or **endangered** under the ESA. A species is considered threatened if it is likely to become an endangered species in the foreseeable future throughout a significant portion of its range. A species is considered endangered if it is in danger of extinction throughout a significant portion of its range. In addition to some marine mammals and all sea turtles, several Pacific salmon stocks are now listed as threatened or endangered. ❑

Appendix 5

Common and Scientific Names of Species

Unit 1: Northeast Demersal Fisheries
Principal Groundfish and Flounders
- Atlantic cod, *Gadus morhua*
- Haddock, *Melanogrammus aeglefinus*
- Pollock, *Pollachius virens*
- Redfish, *Sebastes* spp.
- Silver hake, *Merluccius bilinearis*
- Red hake, *Urophycis chuss*
- Yellowtail flounder, *Pleuronectes ferrugineus*
- Winter flounder, *Pseudopleuronectes americanus*
- Summer flounder, *Paralichthys dentatus*
- Witch flounder, *Glyptocephalus cynoglossus*
- American plaice, *Hippoglossoides platessoides*
- Windowpane, *Scophthalmus aquosus*

Skates and Spiny Dogfish
- Spiny dogfish, *Squalus acanthias*
- Little skate, *Raja erinacea*
- Winter skate, *R. ocellata*
- Barndoor skate, *R. laevis*
- Thorny skate, *R. radiata*
- Brier skate, *R. eglanteria*
- Leopard skate, *R. garmani*
- Smooth-tailed skate, *R. senta*

Other Finfish
- White hake, *Urophycis tenuis*
- Goosefish, *Lophius americanus*
- Cusk, *Brosme brosme*
- Ocean pout, *Macrozoarces americanus*
- Sculpins, Family Cottidae
- Searobins, Family Triglidae
- Scup, *Stenotomus chrysops*
- Tilefish, *Lopholatilus chamaeleonticeps*
- Wolffishes, *Anarhichas* spp.
- Atlantic argentine, *Argentina silus*
- Black sea bass, *Centropristis striata*
- Smooth dogfish, *Mustelus canis*
- Spot, *Leiostomus xanthurus*
- Weakfish, *Cynoscion regalis*
- Atlantic halibut, *Hippoglossus hippoglossus*

Unit 2: Northeast Pelagic Fisheries
Atlantic (sea) herring, *Clupea harengus*
Atlantic mackerel, *Scomber scombrus*
Butterfish, *Peprilus triacanthus*
Bluefish, *Pomatomus saltatrix*
Long-finned squid, *Loligo pealei*
Short-finned squid, *Illex illecebrosus*

Unit 3: Atlantic Anadromous Fisheries
Atlantic salmon, *Salmo salar*
American shad, *Alosa sapidissima*
River herring (alewife), *Alosa pseudoharengus*
Striped bass, *Morone saxatilis*
Atlantic sturgeon, *Acipenser oxyrhynchus*
Blueback herring, *Alosa aestivalis*
Shortnose sturgeon, *Acipenser brevirostrum*
Rainbow smelt, *Osmerus mordax*

Unit 4: Northeast Invertebrate Fisheries
Sea scallop, *Placopecten magellanicus*
American lobster, *Homarus americanus*
Surfclam, *Spisula solidissima*
Ocean quahog, *Arctica islandica*
Northern shrimp, *Pandalus borealis*

Unit 5: Atlantic Highly Migratory Pelagic Fisheries
Swordfish, *Xiphias gladius*
Billfishes
- Sailfish, *Istiophorus platypterus*
- Blue marlin, *Makaira nigricans*
- White marlin, *Tetrapturus albidus*
- Longbill spearfish, *Tetrapturus pfluegeri*
- Atlantic bluefin tuna, *Thunnus thynnus*

Other Tunas
- Albacore, *Thunnus alalunga*
- Bigeye tuna, *Thunnus obesus*
- Blackfin tuna, *Thunnus atlanticus*
- Yellowfin tuna, *Thunnus albacares*
- Little tunny, *Euthynnus alletteratus*
- Skipjack tuna, *Katsuwonus pelamis*
- Bullet tuna, *Auxis rochei*
- Frigate tuna, *Auxis thazard*

Unit 6: Atlantic Sharks
Pelagic Sharks
- Thresher shark, *Alopias vulpinus*
- Bigeye thresher, *Alopias superciliosus*
- Oceanic whitetip shark, *Carcharhinus longimanus*
- Sevengill shark, *Heptrachias perlo*
- Sixgill shark, *Hexanchus griseus*
- Bigeye sixgill shark, *Hexanchus vitulus*
- Shortfin mako, *Isurus oxyrinchus*
- Longfin mako, *Isurus paucus*
- Porbeagle, *Lamna nasus*
- Blue shark, *Prionace glauca*

Large Coastal Sharks
- Sandbar shark, *Carcharhinus plumbeus*
- Reef shark, *Carcharhinus perezi*
- Blacktip shark, *Carcharhinus limbatus*
- Dusky shark, *Carcharhinus obscurus*
- Spinner shark, *Carcharhinus brevipinna*
- Silky shark, *Carcharhinus falciformis*
- Bull shark, *Carcharhinus leucas*
- Bignose shark, *Carcharhinus altimus*
- Galapagos shark, *Carcharhinus galapagensis*
- Night shark, *Carcharhinus signatus*
- White shark, *Carcharodon carcharias*
- Basking shark, *Cetorhinus maximus*
- Tiger shark, *Galeocerdo cuvier*
- Nurse shark, *Ginglymostoma cirratum*
- Lemon shark, *Negaprion brevirostris*
- Ragged-tooth shark, *Odontaspis ferox*
- Whale shark, *Rhincodon typus*
- Scalloped hammerhead, *Sphyrna lewini*
- Great hammerhead, *Sphyrna mokarran*
- Smooth hammerhead, *Sphyrna zygaena*

Small Coastal Sharks
- Finetooth shark, *Carcharhinus isodon*
- Blacknose shark, *Carcharhinus acronotus*
- Atlantic sharpnose shark, *Rhizoprionodon erraenovae*
- Caribbean sharpnose shark, *Rhizoprionodon porosus*
- Bonnethead, *Sphyrna tiburo*
- Atlantic angel shark, *Squatina dumeril*

Unit 7: Atlantic/Gulf of Mexico Coastal Migratory Pelagic Fisheries

King mackerel (Atlantic/Gulf), *Scomberomorus cavalla*
Spanish mackerel (Atlantic/Gulf), *Scomberomorus maculatus*
Cobia, *Rachycentron canadum*
Cero (mackerel), *Scomberomorus regalis*
Dolphin, *Coryphaena hippurus*

Unit 8: Atlantic/Gulf of Mexico/Caribbean Reef Fish Fisheries

Black snapper, *Apsilus dentatus*
Queen snapper, *Etelis oculatus*
Mutton snapper, *Lutjanus analis*
Schoolmaster, *Lutjanus apodus*
Blackfin snapper, *Lutjanus buccanella*
Red snapper, *Lutjanus campechanus*
Cubera snapper, *Lutjanus cyanopterus*
Gray snapper, *Lutjanus griseus*
Mahogany snapper, *Lutjanus mahogoni*
Dog snapper, *Lutjanus jocu*
Lane snapper, *Lutjanus synagris*
Silk snapper, *Lutjanus vivanus*
Yellowtail snapper, *Ocyurus chrysurus*
Vermilion snapper, *Rhomboplites aurorubens*
Wenchman, *Pristipomoides aquilonaris*
Voraz, *Pristipomoides macrophthalmus*
Bank sea bass, *Centropristis ocyurus*
Rock sea bass, *Centropristis philadelphica*
Black sea bass, *Centropristis striata*
Dwarf sand perch, *Diplectrum bivittatum*
Sand perch, *Diplectrum formosum*
Rock hind, *Epinephelus adscensionis*
Graysby, *Epinephelus cruentatus*
Speckled hind, *Epinephelus drummondhayi*
Yellowedge grouper, *Epinephelus flavolimbatus*
Coney, *Epinephelus fulvus*
Red hind, *Epinephelus guttatus*
Jewfish, *Epinephelus itajara*
Red grouper, *Epinephelus morio*
Misty grouper, *Epinephelus mystacinus*
Warsaw grouper, *Epinephelus nigritus*
Snowy grouper, *Epinephelus niveatus*
Nassau grouper, *Epinephelus striatus*
Black grouper, *Mycteroperca bonaci*
Yellowmouth grouper, *Mycteroperca interstitialis*
Gag, *Mycteroperca microlepis*
Scamp, *Mycteroperca phenax*
Tiger grouper, *Mycteroperca tigris*
Yellowfin grouper, *Mycteroperca venenosa*
Wreckfish, *Polyprion americanus*
Sheepshead, *Archosargus probatocephalus*
Sea bream, *Archosargus rhomboidalis*
Grass porgy, *Calamus arctifrons*
Jolthead porgy, *Calamus bajonado*
Saucereye porgy, *Calamus calamus*
Whitebone porgy, *Calamus leucosteus*
Knobbed porgy, *Calamus nodosus*
Sheepshead porgy, *Calamus penna*
Pluma, *Calamus pennatula*
Littlehead porgy, *Calamus proridens*
Pinfish, *Lagodon rhomboides*
Red porgy, *Pagrus pagrus*
Longspine porgy, *Stenotomus caprinus*
Scup, *Stenotomus chrysops*
Black margate, *Anisotremus surinamensis*
Porkfish, *Anisotremus virginicus*
Margate, *Haemulon album*
Tomtate, *Haemulon aurolineatum*
Smallmouth grunt, *Haemulon chrysargyreum*
French grunt, *Haemulon flavolineatum*
Spanish grunt, *Haemulon macrostomum*
Cottonwick, *Haemulon melanurum*
Sailors choice, *Haemulon parra*
White grunt, *Haemulon plumieri*
Bluestriped grunt, *Haemulon sciurus*
Pigfish, *Orthopristis chrysoptera*

Goldface tilefish, *Caulolatilus chrysops*
Blackline tilefish, *Caulolatilus cyanops*
Anchor tilefish, *Caulolatilus intermedius*
Blueline (grey) tilefish, *Caulolatilus microps*
Tilefish (golden), *Lopholatilus chamaeleonticeps*
Sand tilefish, *Malacanthus plumieri*
Gray triggerfish, *Balistes capriscus*
Queen triggerfish, *Balistes vetula*
Ocean triggerfish, *Canthidermis sufflamen*
Black durgon, *Melichthys niger*
Sargassum triggerfish, *Xanthichthys ringens*
Spanish hogfish, *Bodianus rufus*
Hogfish, *Lachnolaimus maximus*
Puddingwife, *Halichoeres radiatus*
Pearly razorfish, *Hemipteronotus novacula*
Yellow jack, *Caranx bartholomaei*
Blue runner, *Caranx crysos*
Crevalle jack, *Caranx hippos*
Horse-eye jack, *Caranx latus*
Black jack, *Caranx lugubris*
Bar jack, *Caranx ruber*
Greater amberjack, *Seriola dumerili*
Lesser amberjack, *Seriola fasciata*
Almaco jack, *Seriola rivoliana*
Squirrelfish, *Holocentrus adscensionis*
Longspine squirrelfish, *Holocentrus rufus*
Yellow goatfish, *Mulloidichthys martinicus*
Spotted goatfish, *Pseudupeneus maculatus*
Foureye butterflyfish, *Chaetodon capistratus*
Spotfin butterflyfish, *Chaetodon ocellatus*
Banded butterflyfish, *Chaetodon striatus*
Queen angelfish, *Holacanthus ciliaris*
Rock beauty, *Holacanthus tricolor*
Gray angelfish, *Pomacanthus arcuatus*
French angelfish, *Pomacanthus paru*
Midnight parrotfish, *Scarus coelestinus*
Blue parrotfish, *Scarus coeruleus*
Striped parrotfish, *Scarus croicensis*
Rainbow parrotfish, *Scarus guacamaia*
Princess parrotfish, *Scarus taeniopterus*
Queen parrotfish, *Scarus vetula*
Redband parrotfish, *Sparisoma aurofrenatum*
Redtail parrotfish, *Sparisoma chrysopterum*
Stoplight parrotfish, *Sparisoma viride*
Ocean surgeonfish, *Acanthurus bahianus*
Doctorfish, *Acanthurus chirurgus*
Blue tang, *Acanthurus coeruleus*
Spotted trunkfish, *Lactophrys bicaudalis*
Honeycomb cowfish, *Lactophrys polygonia*
Scrawled cowfish, *Lactophrys quadricornis*
Trunkfish, *Lactophrys trigonus*
Smooth trunkfish, *Lactophrys triqueter*

Unit 9: Southeast Drum & Croaker Fisheries
Red drum, *Sciaenops ocellatus*
Spotted seatrout, *Cynoscion nebulosus*
Silver seatrout, *Cynoscion nothus*
Sand seatrout, *Cynoscion arenarius*
Spot, *Leiostomus xanthurus*
Atlantic croaker, *Micropogonias undulatus*
Black drum, *Pogonias cromis*
Southern kingfish, *Menticirrhus americanus*
Gulf kingfish, *Menticirrhus littoralis*
Northern kingfish, *Menticirrhus saxatilis*

Unit 10: Southeast Menhaden Fisheries
Atlantic menhaden, *Brevoortia tyrannus*
Gulf menhaden, *Brevoortia patronus*

Unit 11: Southeast/Caribbean Invertebrate Fisheries
Spiny Lobsters/Stone Crabs
- Spiny lobster (SE/Caribbean), *Panulirus argus*
- Slipper lobster, *Scyllarides nodifer*
- Stone crab, *Menippe mercenaria*

Shrimp
- Brown shrimp, *Penaeus aztecus*
- White shrimp, *Penaeus setiferus*
- Pink shrimp, *Penaeus duorarum*
- Royal red shrimp, *Hymenopenaeus robustus*
- Seabobs, *Xiphopenaeus kroyeri*
- Rock shrimp, *Sicyonia brevirostris*
- Pacific black tiger shrimp, *Penaeus monodon*
- Pacific white shrimp, *Penaeus vannamei*

Others
- Queen conch, *Strombus gigas*

Units 12 and 13: Pacific Coast and Alaska Salmon
Chinook salmon, *Oncorhynchus tshawytscha*
Coho salmon, *Oncorhynchus kisutch*
Pink salmon, *Oncorhynchus gorbuscha*
Sockeye salmon, *Oncorhynchus nerka*
Chum salmon, *Oncorhynchus keta*

Unit 14: Pacific Coast and Alaska Pelagic Fisheries
Northern anchovy, *Engraulis mordax*
Pacific herring (Alaska), *Clupea harengus pallasi*
Pacific (California) sardine, *Sardinops sagax*
Jack mackerel, *Trachurus symmetricus*
Chub (Pacific) mackerel, *Scomber japonicus*

Unit 15: Pacific Coast Groundfish Fisheries
Pacific hake (whiting), *Merluccius productus*
Sablefish (black cod), *Anoplopoma fimbria*
Dover sole, *Microstomus pacificus*
Thornyheads
- Shortspine thornyhead, *Sebastolobus alascanus*
- Longspine thornyhead, *Sebastolobus altivelis*

Rockfish
- Aurora rockfish, *Sebastes aurora*

Bank rockfish, *Sebastes rufus*
Black-and-yellow rockfish, *Sebastes chrysomelas*
Blackgill rockfish, *Sebastes melanostomus*
Blue rockfish, *Sebastes mystinus*
Bocaccio, *Sebastes paucispinis*
Bronzespotted rockfish, *Sebastes gilli*
Brown rockfish, *Sebastes auriculatus*
Calico rockfish, *Sebastes dalli*
Canary rockfish, *Sebastes pinniger*
Chilipepper, *Sebastes goodei*
China rockfish, *Sebastes nebulosus*
Copper rockfish, *Sebastes caurinus*
Cowcod, *Sebastes levi*
Darkblotched rockfish, *Sebastes crame*
Dusky rockfish, *Sebastes ciliatus*
Flag rockfish, *Sebastes rubrivinctus*
Gopher rockfish, *Sebastes carnatus*
Grass rockfish, *Sebastes rastrelliger*
Greenblotched rockfish, *Sebastes rosenblatti*
Greenspotted rockfish, *Sebastes chlorostictus*
Greenstriped rockfish, *Sebastes elongatus*
Harlequin rockfish, *Sebastes variegatus*
Honeycomb rockfish, *Sebastes umbrosus*
Kelp rockfish, *Sebastes atrovirens*
Mexican rockfish, *Sebastes macdonaldi*
Olive rockfish, *Sebastes serranoides*
Pacific ocean perch, *Sebastes alutus*
Pink rockfish, *Sebastes eos*
Quillback rockfish, *Sebastes maliger*
Redbanded rockfish, *Sebastes babcocki*
Redstripe rockfish, *Sebastes proriger*
Rosethorn rockfish, *Sebastes helvomaculatus*
Rosy rockfish, *Sebastes rosaceus*
Rougheye rockfish, *Sebastes aleutianus*
Sharpchin rockfish, *Sebastes zacentrus*
Shortbelly rockfish, *Sebastes jordani*
Silvergray rockfish, *Sebastes brevispinis*
Speckled rockfish, *Sebastes ovalis*
Splitnose rockfish, *Sebastes diploproa*
Squarespot rockfish, *Sebastes hopkinsi*
Stripetail rockfish, *Sebastes saxicola*
Tiger rockfish, *Sebastes nigrocinctus*
Treefish, *Sebastes serriceps*
Vermilion rockfish, *Sebastes miniatus*
Widow rockfish, *Sebastes entomelas*
Yelloweye rockfish, *Sebastes ruberrimus*
Yellowmouth rockfish, *Sebastes reedi*
Yellowtail rockfish, *Sebastes flavidus*

Flatfishes
Arrowtooth flounder, *Atheresthes stomias*
Butter sole, *Pleuronectes isolepis*
English sole, *Pleuronectes vetulus*
Flathead sole, *Hippoglossoides elassodon*
Pacific sanddab, *Citharichthys sordidus*
Petrale sole, *Eopsetta jordani*
Rex sole, *Errex zachirus*
Rock sole, *Pleuronectes bilineatus*
Sand sole, *Psettichthys melanostictus*
Starry flounder, *Platichthys stellatus*

Others
Leopard shark, *Triakis semifasciata*
Soupfin shark, *Galeorhinus zyopterus*
Spiny dogfish, *Squalus acanthias*
Big skate, *Raja binocula*
California skat, *Raja inornata*
Longnose skate, *Raja rhina*
Spotted ratfish, *Hydrolagus colliei*
Finescale codling, *Antimora microlepis*
Pacific rattail, *Coryphaenoides acrolepis*
Cabezon, *Scorpaenichthys marmoratus*
Kelp greenling, *Hexagrammos decagrammus*
Lingcod, *Ophiodon elongatus*
Pacific cod, *Gadus macrocephalus*
California scorpionfish, *Scorpaena guttata*

Unit 16: Western Pacific Invertebrate Fisheries
Spiny lobster, *Panulirus marginatus*
Slipper lobster, *Scyllarides squamosus*
Precious corals, Order Zoanthidea, Family Gorgoniidae

Unit 17: Western Pacific Bottomfish and Armorhead Fisheries
Reef Fishes
Silverjaw jobfish, *Aphareus rutilans*
Gray jobfish (uku), *Aprion virescens*
Squirrelfish snapper (ehu), *Etelis carbunculus*
Longtail snapper (onaga), *Etelis coruscans*
Bluestripe snapper (taape), *Lutjanus kasmira*
Yellowtail snapper (yellowtail kalekale), *Pristipomoides auricilla*
Pink snapper (opakapaka), *Pristipomoides filamentosus*
Yelloweye snapper (yelloweye opakapaka), *Pristipomoides flavipinnus*
Pink snapper, (kalekale), *Pristipomoides sieboldii*
Pink snapper, (gindai), *Pristipomoides zonatus*
Giant trevally (white ulua), *Caranx ignobilis*
Black jack, (black ulua), *Caranx lugubris*
Thick lipped trevally, (butaguchi), *Pseudocaranx dentex*
Greater amberjack, (kahala), *Seriola dumerili*
Blacktip grouper, *Epinephelus fasciatus*
Seabass (hapu upu u), *Epinephelus quernus*
Lunartail grouper, *Variola louti*
Ambon emperor, *Lethrinus amboinensis*
Redgill emperor, *Lethrinus rubrioperculatus*

Seamount Fishes
Pelagic armorhead, *Pseudopentaceros richardsoni*
Alfonsino, *Beryx splendens*

Raftfish, *Hyperoglyphe japonica*

Unit 18: Pacific Highly Migratory Pelagic Fisheries

Swordfish, *Xiphias gladius*
Blue marlin, *Makaira nigricans*
Striped marlin, *Tetrapturus audax*
Albacore (North & South), *Thunnus alalunga*
Bigeye tuna, *Thunnus obesus*
Yellowfin tuna, *Thunnus albacares*
Skipjack tuna, *Katsuwonus pelamis*
Other Pelagics
- Sailfish, *Istiophorus platypterus*
- Black marlin, *Makaira indica*
- Shortbill spearfish, *Tetrapturus angustirostris*
- Dolphin (mahimahi), *Coryphaena hippurus*
- Oceanic sharks, Families—Carcharhinidae, Alopiidae, Sphyrnidae, and Lamnidae Wahoo, *Acanthocybium solandri*

Unit 19: Alaska Groundfish Fisheries

Walleye (Alaska) pollock, *Theragra chalcogramma*
Pacific cod, *Gadus macrocephalus*
Sablefish (black cod), *Anoplopoma fimbria*
Yellowfin sole, *Pleuronectes asper*
Pacific halibut, *Hippoglossus stenolepis*
Arrowtooth flounder, *Atheresthes stomias*
Greenland halibut, *Reinhardtius hippoglossoides*
Rock sole, *Pleuronectes bilineatus*
Atka mackerel, *Pleurogrammus monopterygius*
Other Flatfishes
- Flathead sole, *Hippoglossoides elassodon*
- Alaska plaice, *Pleuronectes quadrituberculatus*
- Rex sole, *Errex zachirus*
- Butter sole, *Pleuronectes isolepis*
- Longhead dab, *Pleuronectes proboscideus*
- Dover sole, *Microstomus pacificus*
- Starry flounder, *Platichthys stellatus*

Rockfishes
- Pacific ocean perch, *Sebastes alutus*
- Thornyhead rockfish, *Sebastolobus* spp.
- Roughey rockfish, *Sebastes aleutianus*
- Dusky rockfish, *Sebastes ciliatus*
- Northern rockfish, *Sebastes polyspinis*
- Shortspine thornyhead, *Sebastolobus alascanus*
- Shortraker rockfish, *Sebastolobus borealis*
- Darkblotched rockfish, *Sebastes crameri*
- Sharpchin rockfish, *Sebastes zacentrus*
- Yelloweye rockfish, *Sebastes ruberrimus*
- Blue rockfish, *Sebastes mystinus*

Others
- Rattail, *Coryphaenoides* spp.
- Skates, *Raja* spp.
- Squids, *Sepioidea and Teuthoidea*
- Octopus, *Octopoda*

Unit 20: Alaska Shellfish Fisheries

Red king crab, *Paralithodes camtschatica*
Blue king crab, *Paralithodes platypus*
Golden (brown) king crab, *Lithodes aequispina*
Tanner (snow) crab, *Chionoecetes bairdi, C. opilio*
Sea Snails, *Neptunea pribiloffensis, N. heros, N. lyrata, N. ventricosa, Fusitriton oregonensis, Buccinum angulossum, B. plectrum, B. scalariforme, B. polare, Volutopsius middindorffii, V. fragilis, Plicifusus kroyeri, Pyrulofusus deformis*

Unit 21: Nearshore Fisheries

Sharks and Rays (in part), Class Elasmobranchiomorphi
White sturgeon, *Acipenser transmontanus*
Tarpon, *Megalops atlanticus*
Ladyfish, *Elops saurus*
Bonefish, *Albula vulpes*
Milkfish, *Chanos chanos*
American eel, *Anguilla rostrata*
Moray eels, Family Muraenidae
Other shads, herrings, *Alosa aestivalis, Alosa alabamae, Alosa mediocris, Dorosoma cepedianum, Dorosoma petenense, Etrumeus teres, Harengula clupeola, Harengula humeralis, Harengula jaguana*
Atlantic thread herring, *Opisthonema oglinum*
Gulf butterfish, *Peprilus burti*
Spanish sardine, *Sardinella aurita*
Smelts, *Hypomesus pretiosus, Allosmerus elongatus, Spirinchus starksi*
Eulachon, *Thaleichthys pacificus*
Ballyhoo, *Hemiramphus brasiliensis*
Common snook, *Centropomus undecimalis*
Striped bass (Pacific), *Morone saxatilis*
Florida pompano, *Trachinotus carolinus*
Permit, *Trachinotus falcatus*
Mackerel scad or opelu, *Decapterus macarellus*
Bigeye scad, *Selar crumenophthalmus*
Snappers, *Etelis, Lutjanus* and *Pristipomoides* spp.
Soldierfishes, *Myripristis spp.*
Goatfishes, Family Mullidae
Emperors, Family Lethrinidae
Rabbitfishes, Family Siganidae
Yellowtail, *Seriola lalandi*
California (Pacific) barracuda, *Sphyraena argentea*
California corbina, *Menticirrhus undulatus*
White seabass, *Atractoscion nobilis*
Pacific croakers, *Roncador stearnsi, Umbrina roncador, Genyonemus lineatus*
Kelp bass, *Paralabrax clathratus*
Sand basses, *P. nebulifer and P. maculatofasciatus*
California sheephead, *Semicossyphus pulcher*
Surfperches, Family Embiotocidae

Mullets, Family Mugilidae
Tautog, *Tautoga onitis*
Opah, *Lampris guttatus*
Pacific bonito, *Sarda chiliensis*
California halibut, *Paralichthys californicus*
Squirrelfishes, Family Holocentridae
Parrotfishes, Family Scaridae
Surgeonfishes, Family Acanthuridae
Groupers, *Epinephelus, Variola*, and *Cephalopholis* spp.
Bigeyes, Family Priacanthidae
Abalone, *Haliotis* spp.
Pacific shrimps, Family Pandalidae
Dungeness crab, *Cancer magister*
Atlantic rock crab, *Cancer irroratus*
Jonah crab, *Cancer borealis*
Red rock crab, *Cancer productus*
Yellow rock crab, *C. anthonyi*
Brown rock crab, *C. antennarius*
Sheep crab *Loxorhynchus grandis*
California spiny lobster, *Panulirus interruptus*
California market squid, *Loligo opalescens*
Blue crab, *Callinectes sapidus*
Blue mussel, *Mytilus edulis*
Pacific razor clam, *Siliqua patula*
Pismo clam, *Tivela stultorum*
Pacific hard clams, Family Veneridae
Northern quahog, *Mercenaria mercenaria*
Softshell, *Mya arenaria*
Bay scallop, *Argopecten irradians*
Atlantic calico scallop, *Argopecten gibbus*
Eastern oyster (Atlantic), *Crassostrea virginica*
Pacific oyster, *Crassostrea gigas*
Sea urchins, *Strongylocentrotus* spp.
Sea cucumbers, *Parastichopus* spp.
Palolo worms, *Eunice viridis*

Units 22 and 23: Alaska and Pacific Marine Mammals
Eastern Tropical Pacific Dolphins
  Spinner dolphin, *Stenella longirostris*
  Spotted dolphin (Pacific), *Stenella attenuata*
  Striped dolphin, *Stenella coeruleoalba*
  Common dolphin, *Delphinus delphis*
Bowhead whale, *Balaena mysticetus*
Gray whale, *Eschrichtius robustus*
Humpback whale, *Megaptera novaeangliae*
Northern (steller) sea lion, *Eumetopias jubatus*
Northern fur seal, *Callorhinus ursinus*
Hawaiian monk seal, *Monachus schauinslandi*
California sea lion, *Zalophus californianus*
Other Marine Mammal
  Dall's porpoise, *Phocoenoides dalli*
  Harbor porpoise, *Phocoena phocoena*
  Northern right-whale dolphin, *Lissodelphis borealis*
  Whitesided dolphin, *Lagenorhynchus obliquidens*
  Harbor seal, *Phoca vitulina*
  Ribbon seal, *Histriophoca fasciata*
  Blue whale, *Balaenoptera musculus*
  Guadalupe fur seal, *Arctocephalus townsendi*

Unit 24: Atlantic Marine Mammals
Right whale, *Eubalaena glacialis*
Humpback whale, *Megaptera novaeangliae*
Longfin pilot whale, *Globicephala melas*
Shortfin pilot whale, *Globicephala macrorhynchus*
Harbor porpoise, *Phocoena phocoena*
Bottlenose dolphin, *Tursiops truncatus*
Harbor seal, *Phoca vitulina*
Grey seal, *Halichoerus grypus*
Other Marine Mammal
  Fin whale, *Balaenoptera physalus*
  Whitesided dolphin, *Lagenorhynchus acutus*
  Striped dolphin, *Stenella coeruleoalba*
  Spotted dolphin (Atlantic), *Stenella plagiodon*
  Beaked whales, *Mesoplodon* spp.
  Bottlenose whales, *Hyperoodon* spp.

Unit 25: Sea Turtles
Kemp's ridley sea turtle, *Lepidochelys kempi*
Olive ridley sea turtle, *Lepidochelys olivacea*
Leatherback sea turtle, *Dermochelys coriacea*
Green sea turtle, *Chelonia mydas*
Loggerhead sea turtle, *Caretta caretta*
Hawksbill sea turtle, *Eretmochelys imbricata*

Appendix 6

Acronyms and Abbreviations

ABC	Acceptable biological catch
ADF&G	Alaska Department of Fish and Game
AFSC	Alaska Fisheries Science Center
ASMFC	Atlantic States Marine Fisheries Commission
ATCA	Atlantic Tunas Convention Act
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CI	Confidence intervals
CL	Confidence limits
cm	Centimeter
CNMI	Commonwealth of the Northern Mariana Islands
CPUE	Catch per unit of effort
CPY	Current potential yield
CV	Coefficient of variation
CWP	Central-Western Pacific Ocean
DDT	DichloroDiphenylTrichloroethane
EBS	Eastern Bering Sea
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency
ESA	Endangered Species Act of 1973
ETP	Eastern Tropical Pacific Ocean
F_{max}	Rate of fishing mortality that results in the maximum level of yield per recruit
fm	Fathom
F	Instantaneous fishing mortality rate
FMC	Fishery Management Council
FMP	Fishery Management Plan
GLOBEC	Global ocean ecosystems dynamics
GIFA	Governing International Fisheries Agreement
GSMFC	Gulf States Marine Fisheries Commission
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICNAF	International Commission for the Northwest Atlantic Fisheries
IFQ	Individual fishing quota
ITQ	Individual transferable quota
INPFC	International North Pacific Fisheries Commission
IPHC	International Pacific Halibut Commission
IWC	International Whaling Commission
kg	Kilogram
LME	Large marine ecosystem
LMR	Living marine resource(s)
LTPY	Long-term potential yield
m	Meter
M	Instantaneous rate of natural mortality
MFCMA	Magnuson Fisheries Conservation and Management Act of 1976
MHI	Main Hawaiian Islands
mm	Millimeter
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service, Department of Interior
MSY	Maximum sustainable yield
NASCO	North Atlantic Salmon Conservation Organization

NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
nmi	Nautical mile
NOAA	National Oceanic and Atmospheric Administration
NPAFC	North Pacific Anadromous Fish Commission
NWFSC	Northwest Fisheries Science Center
NWHI	Northwestern Hawaiian Islands
OLO	Our Living Oceans
OY	Optimum yield
OSP	Optimum sustainable population
PCB	Polychlorinated Biphenyls
PBR	Potential Biological Removal
PICES	North Pacific Marine Science Organization
PSC	U.S.-Canada Pacific Salmon Commission
PSP	Paralytic shellfish poisoning
RAY	Recent average yield
SE	Standard error
SEFSC	Southeast Fisheries Science Center
SNE	Southern New England
SPR	Spawner per recruit
SSB	Spawning stock biomass
SWFSC	Southwest Fisheries Science Center
t, mt	Metric ton
TAC	Total allowable catch
TED	Turtle excluder device
UNGA	United Nations General Assembly
USFWS	U.S. Fish and Wildlife Service

DEPARTMENT OF COMMERCE
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